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DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

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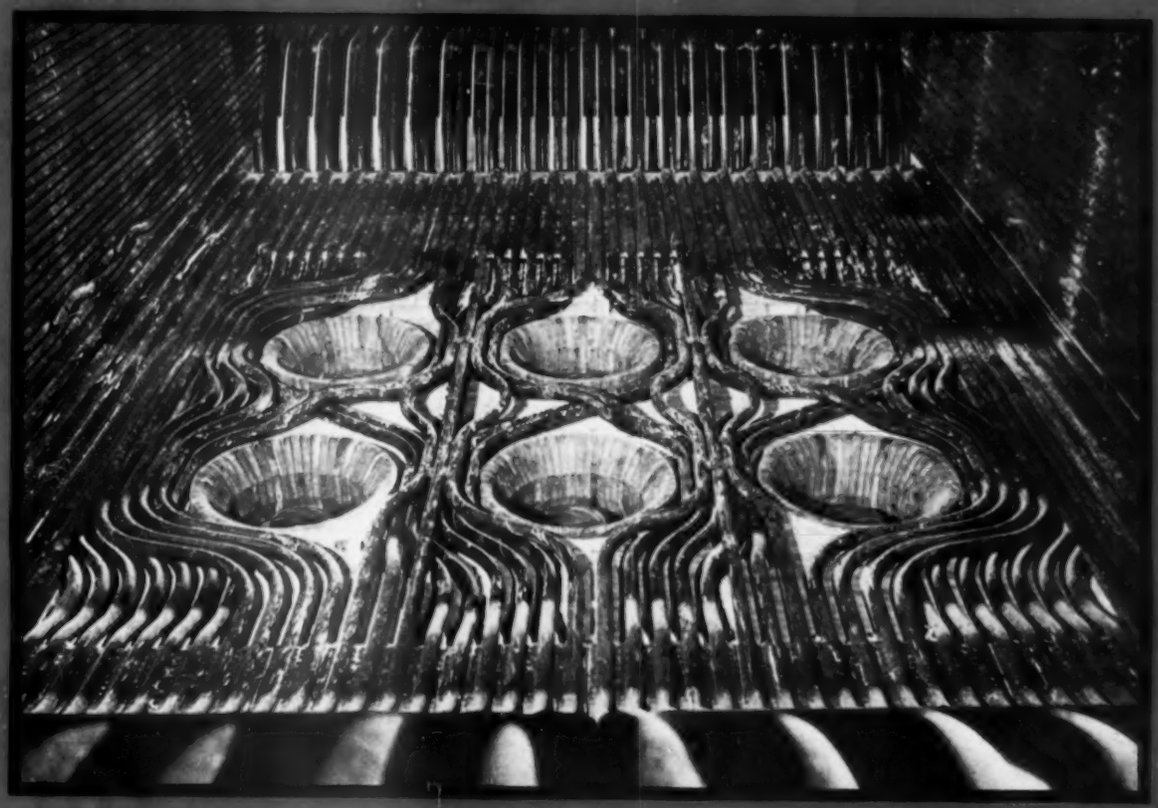

Front wall of pulverized coal-fired furnace

New Havana Power Station ▶

A.S.M.E. Annual Meeting ▶

Removal of Silica Deposits from Steam Turbines ▶

Recent C-E Steam Generating Units for Utilities

LAKESIDE STATION

ROCHESTER GAS AND ELECTRIC CORPORATION

THE C-E Unit, illustrated here, is now in the process of fabrication for the new Lakeside Station of the Rochester Gas and Electric Corporation at Rochester, New York. A second unit, duplicate of this one, has recently been ordered.

These units are designed to produce at maximum continuous capacity 450,000 lb of steam per hr at 1300 psi and 955 F.

They are of the 3-drum type, with additional dry drum and 2-stage superheaters. The arrangement includes a Montaup-type, by-pass damper at the outlet, followed by a C-E Economizer and regenerative-type air heaters.

The furnaces are fully water cooled, employing both finned tubes and closely spaced plain tubes. The basket bottom construction is used discharging to sluice-type ash hoppers.

The units are pulverized coal fired, employing C-E Raymond Bowl Mills and Vertically-Adjustable, Tangential Burners. These burners, in conjunction with thermostatically-controlled Montaup-type dampers, assure accurate regulation of superheat temperatures.

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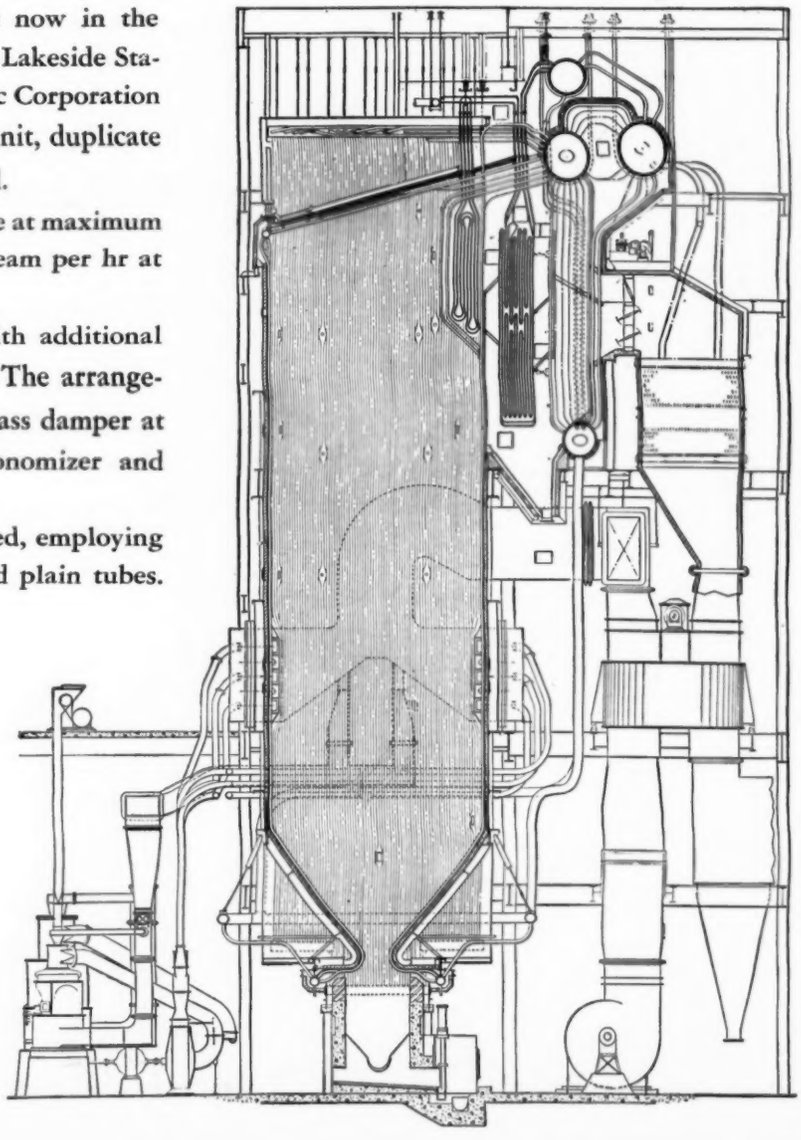

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COMBUSTION

DEVOTED TO THE ADVANCEMENT OF STEAM PLANT DESIGN AND OPERATION

VOLUME NINETEEN NUMBER SIX

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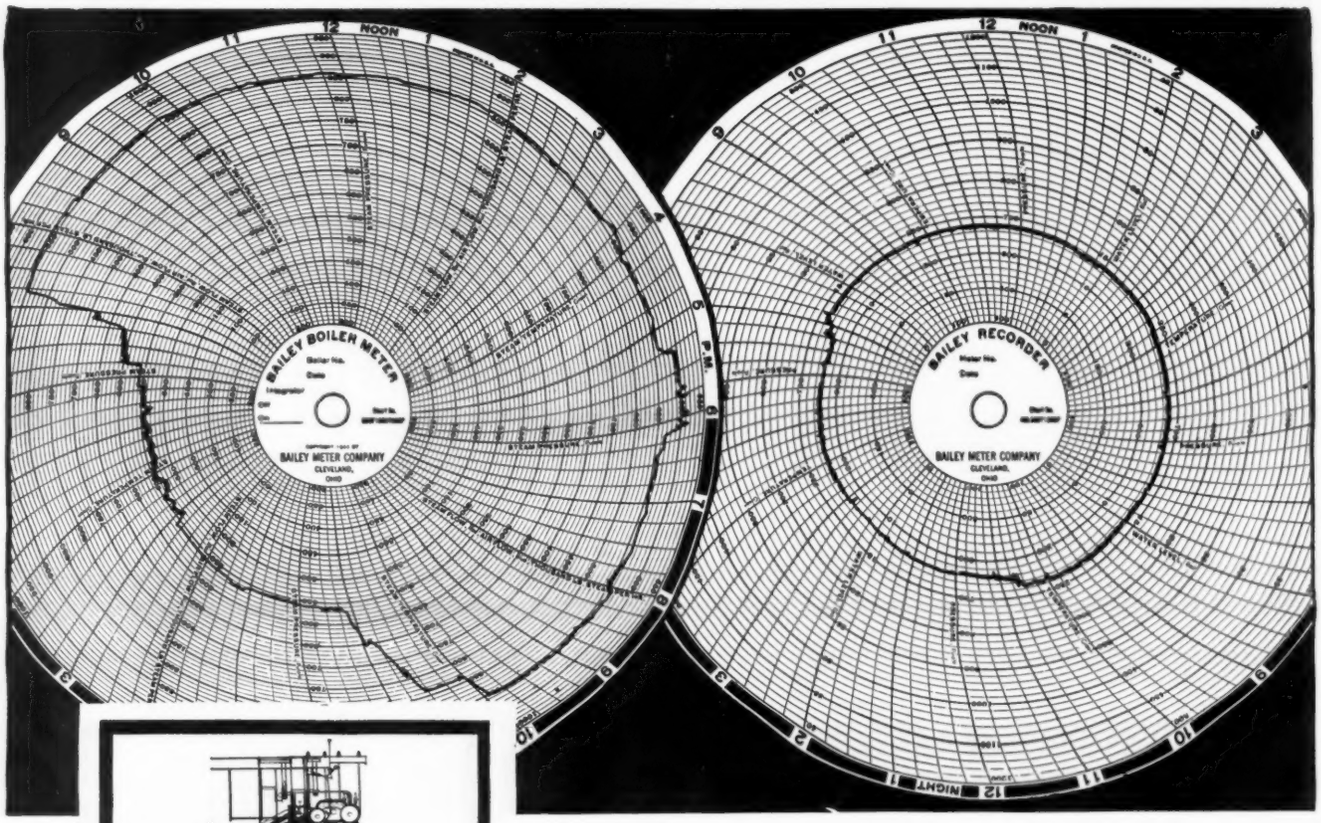

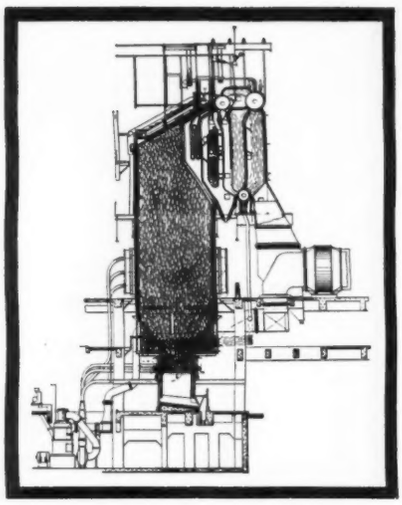

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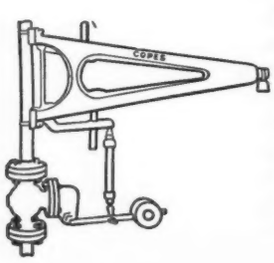

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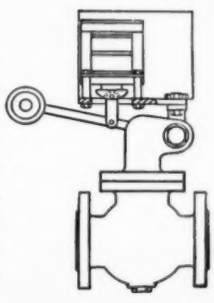


EDITORIAL

The Future of Coal

Despite what atomic energy may hold for the future and the increasing demand for liquid and gaseous fuels which is outstripping present production, coal will continue to be the basic source of our energy supply for many years to come. This may take the form of solid coal, synthetic oils or gas. It is likely that all three forms will be required to meet the demands of manufacturing industries, railroads and other means of transportation, public utilities and domestic users.

The importance of coal and its position in the future were discussed in a talk by Fred S. McConnell, president of the National Coal Association, during the Annual Meeting of the A.S.M.E. at Atlantic City. He said, "an abundant supply of cheap coal has been the foundation of the greatest industrial machine the world has ever seen" and that now "coal is on the threshold of new and undreamed-of conquest."

Today, coal is being mined at an unprecedented rate in the United States, but there is not sufficient production in Europe for her own fuel and energy supply. This results in lower production of steel and textiles, limited transportation, inadequate supplies of by-product fertilizer and less lumber because of the increasing use of timber for fuel. Present U. S. exports of coal, put at 45,000,000 tons yearly, are likely to increase in 1948. As the shortage of mining machinery, supplies and railroad cars is eliminated, U. S. production of coal should expand sufficiently to meet all domestic and export requirements.

Although the demand for oil and gas has reached a new high, the natural source of these fuels is limited, and the rate of discovery of new pools has diminished.

The U. S. Bureau of Mines estimates that oil shale constitutes only 0.8 per cent of the U. S. mineral fuel reserves, petroleum and natural gas 0.2 per cent each, while coal and lignite account for the remaining 98.8 per cent. Present-day consumption of petroleum products, which includes increasing use of fuel oil by railroads and domestic users as well as a demand for gasoline exceeding even the war years, constitutes a serious drain on reserves.

The early need for synthetic fuels is apparent and the coal industry is already taking steps to pioneer this field. A pilot plant, operated jointly by the Pittsburgh Consolidation Coal Co. and Standard Oil Co. of New Jersey, has been erected near Pittsburgh for this purpose. Still another field currently being investigated is the gasification of bituminous coal in the mines to produce gas fuel. The Alabama Power Company, in cooperation with the Bureau of Mines, has been experimenting with this phase to determine possible advantages over conventional mining methods.

The advent of synthetic oil should not lessen the demand for solid fuels. Coal will still be the basic fuel for the power industry; also to produce coke, without which the largest steel industry in the world could not operate; and to meet many other manufacturing needs. Furthermore, it is possible that the success of the pulverized coal gas-turbine locomotive, with efficiencies approaching that of the diesel, may become a formidable competitor of the latter.

The coal industry, confident of its place in the future, is taking steps to strengthen its position with scientific research, new developments and the creation of new uses for coal products. Public relations will also play a prominent part in helping this industry to continue to satisfy the growing demand for fuels, as well as for by-products and many other uses of coal.

Scrap Scarcity

The present acute shortage in steel scrap has been responsible not only for soaring scrap prices, but has been reflected in a more or less tight market in steel, particularly in those plate sizes for which there is a heavy and varied demand.

We all recall the success of the scrap drives during the war, motivated by patriotic fervor; but the bottom of those sources was scraped and there has been little time for new accumulations through usual channels. In fact, were times normal a considerable portion of automobiles now on the roads would have long since reached the scrap lots and much obsolete machinery that is still operating, for lack of available replacement, would have been broken up and sold.

Apparently there has been little attempt to salvage much of the vast tonnage of steel expended or abandoned in the various theaters of war, particularly on certain Pacific islands. Lack of manpower and transportation has been suggested as a possible reason, although with hundreds of idle cargo ships still in the hands of the Government, the transportation problem would appear solvable. A concerted effort in this respect would go far to alleviate the present scrap bottleneck. Proposals have already been made on the floor of Congress with reference to such scrap in Germany.

This leads to the question frequently heard nowadays, as to what effect the Marshall Plan, when in force, will have on the steel situation as a part of our domestic economy. It is, of course, too early to assess this effect, but it undoubtedly will be felt by the capital goods industries, both as to steel availability and prices. It is a problem with which the power plant field is directly concerned.

Illinois Power Company's New HAVANA POWER STATION

By H. E. STEINHOFF

Vice President, Illinois Power Company

Description of ini al installation of 80,000 kw which will be increased to 200,000 kw by 1950, at which time the station will contain five 40,000-kw turbine-generators and seven 285,000-lb-per-hr pulverized-coal-fired boilers. Steam conditions are 850 psi and 900 F at the turbine throttle.

THE first section of Havana Power Station of the Illinois Power Company, consisting of two 40,000-kw turbine-generators and three 285,000-lb-per-hr steam generating units, went into commercial service last August.

This new plant is located on the east bank of the Illinois River, a short distance south of Havana, Ill. and will be tied in, through a 138-kv line, with a second new plant, the Wood River Station. The latter is being constructed on the east bank of the Mississippi River, between Alton and Wood River, about 100 miles distant from Havana. These two plants, when complete, will meet the requirements of a 320,000-kw interconnected system, serving some 440 communities, which heretofore has operated largely with energy purchased from other utilities.

While the initial capacity of Havana is 80,000 kw, a third 40,000-kw unit now on order will go into operation next August, and two more units of like capacity are scheduled for operation in June 1950. This will provide an installed capacity of 200,000 kw, with seven 285,000-lb-per-hr boilers and five 40,000-kw turbine-generators.

Steam Generating Units

Steam conditions are 850 psi, 900 F at the turbine throttle, although the three Combustion Engineering steam generators, comprising the initial installation, are designed for a pressure of 950 psi and 910 F total steam temperature. As will be noted from the cross-section, Fig. 3, these units are of the three-drum type with bare-tube water walls and completely water-cooled basket-

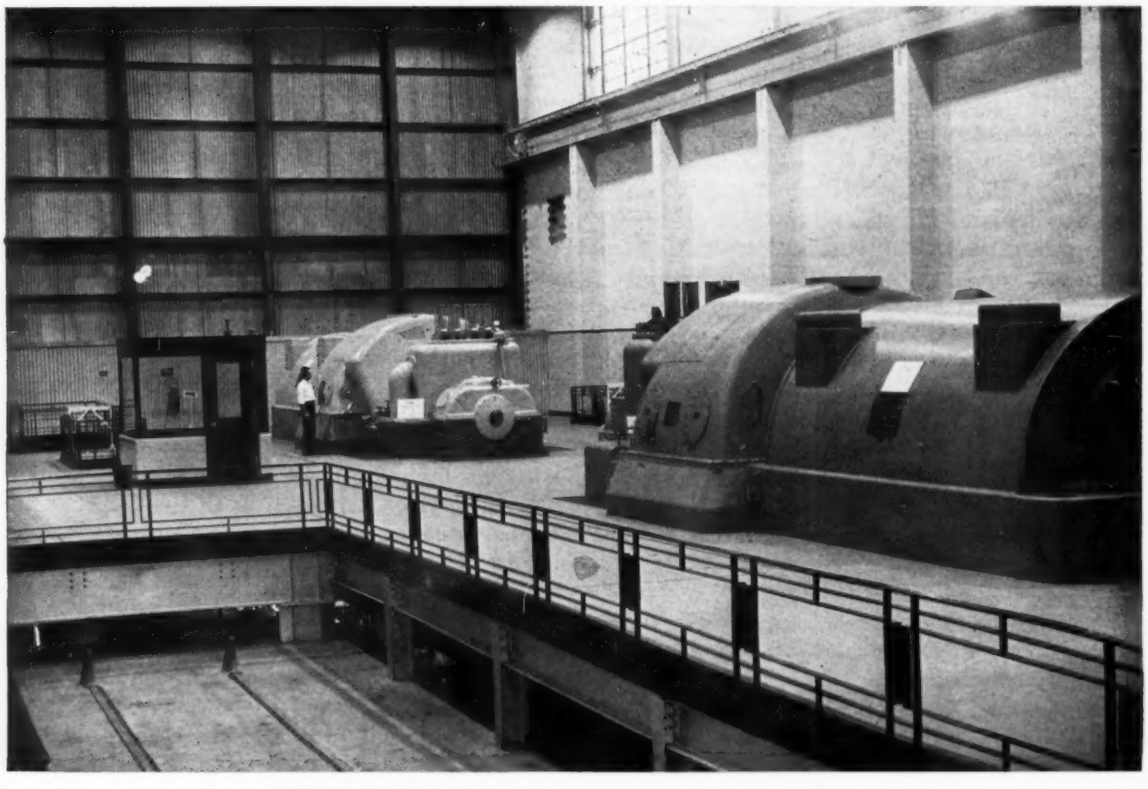


Fig. 1—Turbine room with first two units in service

bottom furnaces. They are corner fired by vertically adjustable tangential burners that are supplied with pulverized coal from 25,000-lb-per-hr C-E Raymond bowl mills, two per boiler. The Elesco superheaters, of 11,600 sq ft surface, are of the two-stage type and superheat control is effected by the vertically adjustable burners in conjunction with remotely operated bypass dampers. Each unit has a C-E two-section tubular air heater which supplies preheated air of 590 F under full load conditions when the gas inlet and outlet temperatures are, respectively, 710 and 350 F. The full-load calculated feedwater temperature is 407 F. A conservative furnace heat release of approximately 18,000 Btu per cu ft is provided by the 20,000-cu ft furnace, which is 20 ft wide and has 7,160 sq ft of waterwall surface.

Each steam generating unit is served by one motor-driven forced-draft fan and one motor-driven induced-draft fan with speed control provided by hydraulic couplings. A 225-ft radial brick stack serves the first three units. Although dust-recovery equipment was not included in the initial plant, provision has been made for its future installation.

L. & N. combustion control system is employed to control the air and coal feed in accordance with steam output, pressure and temperature. It functions by means of an air-loading pressure which varies in response to changes in steam temperature. Full automatic, semi-automatic or manual control is possible by manipulating selector switches on the boiler panel board. Tachometers meter and control fuel input to the mills, and fuel output from them is controlled by means of the exhauster damper. As previously mentioned, the forced- and induced-draft fans are driven by constant-speed motors through variable-speed hydraulic couplings and draft is regulated both by the fan dampers and fan speed. The control system also includes the motor drive equipment for tilting the burners and that for positioning the superheater bypass damper.

Boiler feed is supplied by three 750-gpm motor-driven and one steam turbine-driven pumps, the former being

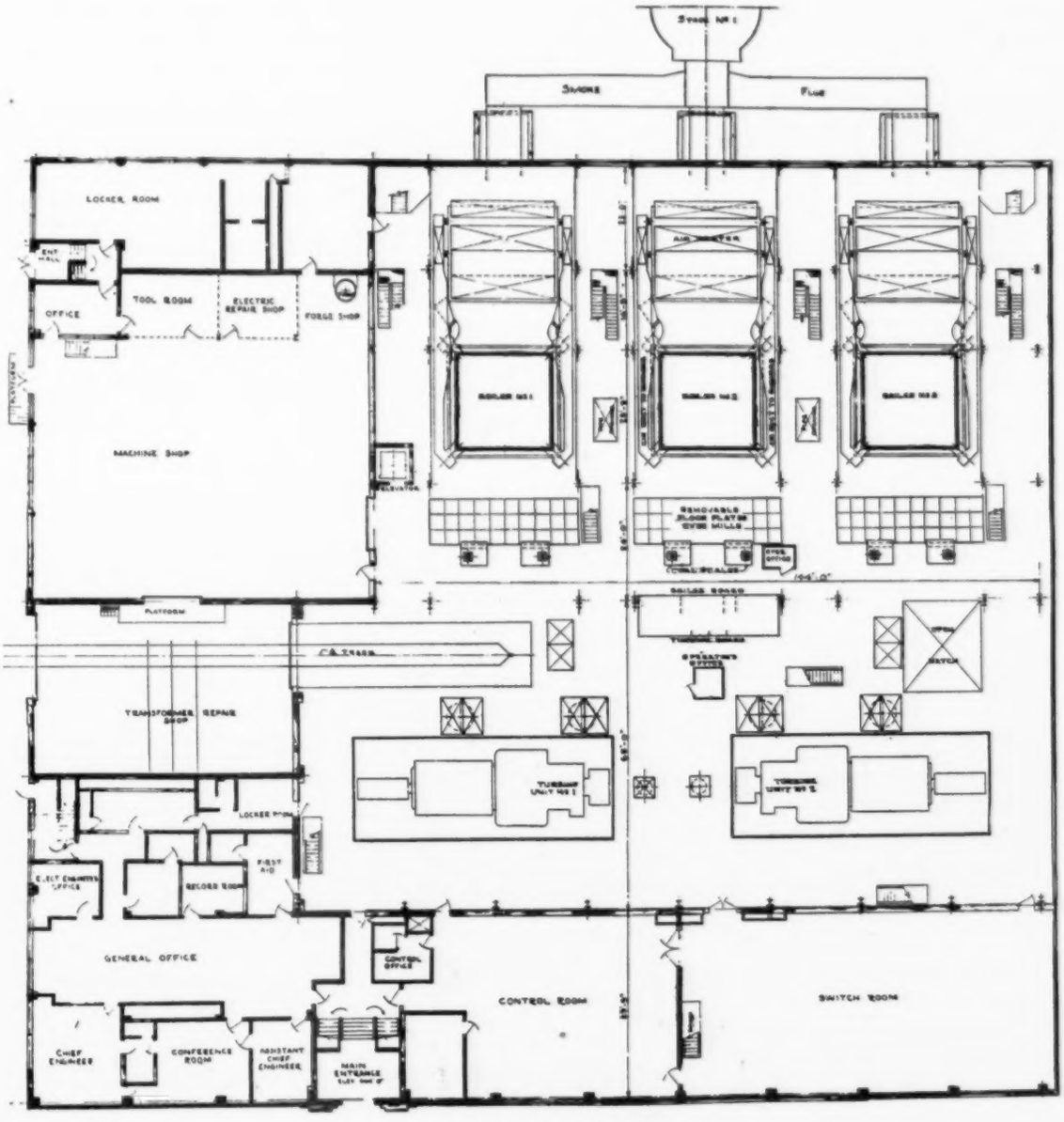


Fig. 2—General plan of station

used for normal operation and the latter for emergency operation and for quick starting. Ordinarily, the pumps take their suction from an elevated deaerating heater, but provision is also made for emergency supply direct from the distilled-water surge tank. Discharge is through the 8th and 4th stage extraction heaters to a header supplying the three boilers. A breakdown orifice in the pump discharge takes care of minimum flow requirements of the pumps.

Coal and Ash Handling

The coal burned at Havana is washed screenings from Fulton County, averaging 10 per cent ash, 17 per cent moisture and 3 per cent sulphur, with a heating vaule of 10,500 Btu per lb. This is delivered chiefly by barge although provision has been made for rail and truck delivery, if necessary. Barge unloading is by means of a two-ton grab bucket, operated from an unloading tower; whereas for rail delivery dump-bottom cars discharging into a track hopper are employed. The coal is then delivered by a 36-in. belt conveyor to a Bradford breaker or direct to storage. Coal is recovered from storage by carryalls and delivered to a reclaiming hopper which discharges to the conveyor leading to the breaker house. A 36-in. belt conveyor delivers coal from the breaker house to the boiler bunkers.

Ashes are handled by a sluice system which includes discharges from the furnace hoppers, the hoppers under the first and rear passes of the boiler, from the breeching hoppers, and from the base of the stack. This ash is sluiced through a pipe line by means of "hydroveyor" water-jet pumps to a fill some distance from the plant. Approximately 40 tons of ashes per hour can be discharged by the system, at which rate around 2000 gal of water per minute at 150 psi would be required.

Generating Units and Condensers

The two 40,000-kw turbine-generating units are of General Electric design of the tandem-compound, double-flow type with 21 stages. The generators are hydrogen-cooled and have direct-connected geared exciters. Other particulars concerning these units are

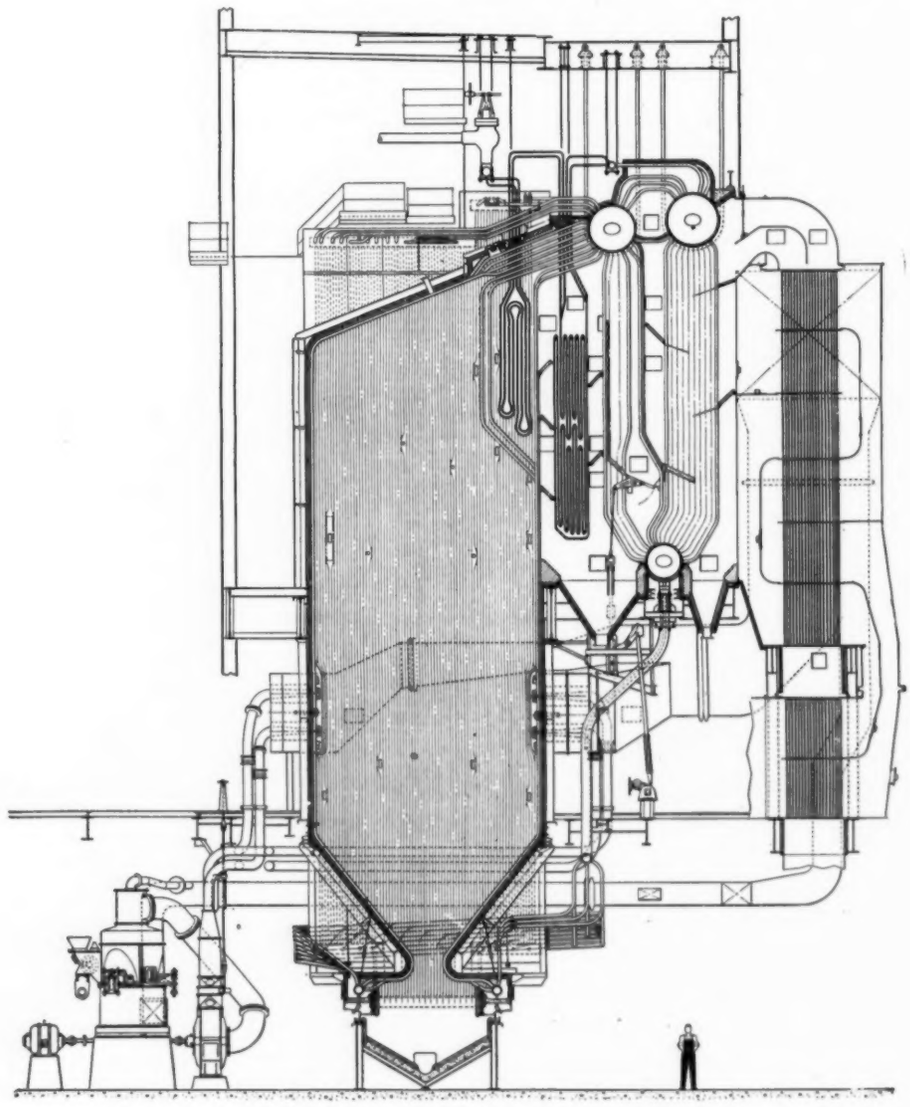


Fig. 3—Cross-section through steam generating unit

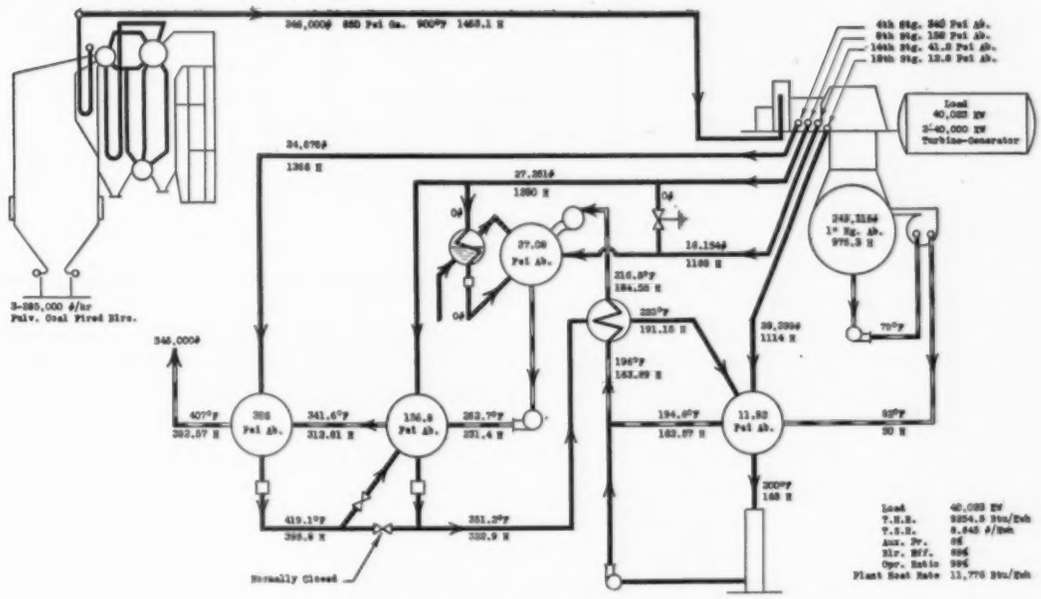


Fig. 4—Flow diagram

rating at 0.8 power factor, 3600 rpm, 3 phase, 60 cycle and 13,800 volts.

A single-pass condenser of 30,000 sq ft surface and employing 1-in. arsenical copper tubes, serves each turbine. The water boxes are arranged to permit backwashing and cleaning while the condenser is in operation. Each condenser is supplied with circulating water from the Illinois River by two 34,000-gpm vertical motor-driven pumps. These also supply house service and the ash-sluice pumps. Two motor-driven condensate pumps and one twin-element two-stage steam ejector are provided for each condenser. The intake and discharge tunnels have been designed to take care of the ultimate installation. An automatic intermittent circulating-water chlorination system for control of slime and algae accumulations is housed in a separate building arranged for drum and tank car deliveries of chlorine.

Feedwater heating is accomplished by four stages of turbine extraction, three closed feedwaters and one direct-contact deaerating heater, as indicated in Fig. 4.

A separate three-element feedwater control system is provided for each of the steam-generating units. These proportion the feed in accordance with the steam flow and the water level in the drum.

Auxiliary Drive

Motor drive is employed for all station auxiliaries, with the exception of the reserve boiler feed pump which has turbine drive. In all, this motor drive for the initial section of the plant aggregates about 12,000 hp, or about 11 per cent of the station capacity. Motors driving boiler feed pumps, forced-and induced-draft fans, pulverizers, compressors and other large drives, except coal handling, all operate at 2400 volts. Those driving the coal-handling equipment, as well as small motors of 40 hp and less, operate at 440 volts. In general, controls for starting the auxiliaries have been placed on the turbine or boiler panels on the main floor or on the pump control boards in the basement.

Sargent & Lundy, Chicago, were the consulting engineers on the design of this plant.

PRINCIPAL MECHANICAL EQUIPMENT

Steam-Generating Units

Three 285,000-lb-per-hr, three-drum, bent-tube *Combustion Engineering* boilers, 875 psig working pressure, 910 F steam temperature. Furnace tangentially fired by vertically adjustable burners supplied by *C-E Raymond* bowl mills. Boiler heating surface 12,065 sq ft; plain tube furnace walls 7160 sq ft; *Elesco* superheater (two-stage) 11,600 sq ft; furnace volume 20,230 cu ft. *C-E* tubular air preheater, 51,400 sq ft. Calculated full-load efficiency 85.2 per cent.

Turbine-Generators

Two 50,000-kva (0.8 pf), tandem compound, 21-stage, 3600-rpm, hydrogen-cooled *General Electric* units, operating at 850 psig, 900 F and extraction at the 4th, 8th, 14th and 18th stages.

Condensing Equipment

Two 30,000-sq ft, single-pass *Worthington* condensers; with two *Worthington* 500-gpm motor-driven condensate pumps per condenser and two 34,000 gpm motor-driven circulating pumps per condenser. Two *Link Belt* intake screens.

Feedwater System

Three motor-driven and one turbine-driven 750-gpm, 3650-rpm *Worthington* boiler feed pumps. Motors 700 hp, 2200 volts and *G. E.* turbine 719 hp.

Two 250-gpm, 1750-rpm *Worthington* centrifugal motor-driven heater-drain pumps.

Elliott direct-contact, 410,000-lb-per-hr deaerating heaters. *Foster-Wheeler* stage heaters—4th stage, 1400-sq ft vertical 4-pass; 8th stage, 1550-sq ft vertical 4-pass; 18th stage, 1765-sq-ft horizontal 4-pass; 8th stage drain cooler, 547-sq ft horizontal 2-pass.

Foster Wheeler 16,000-lb-per-hr, single-effect evaporators.

Induced-Draft Fans

One 139,000-cfm, 752-rpm, 10.85-in. static draft *Buffalo Forge* fan per boiler, each driven by a 600-hp, 2200-volt motor.

Forced-Draft Fans

One 82,500-cfm, 1000-rpm, 10.6-in. static discharge pressure *Buffalo Forge* fan per boiler, each driven by a 300-hp, 2200-volt motor.

Coal-Handling Equipment

Robins conveying system of 300/350 tons per hr, with 2-yd bucket unloading tower hoist operated by 300-hp motor. Belt conveyors all 36 in.

Hammermill breaker—*Pennsylvania Crusher Co.*
Magnetic pulley—*Dings Magnetic Separator Co.*
Weightometers—*Merrick Scale Co.*
Coal sampler—*Geary Jennings.*
Barge shifter equipment—*Robins Conveyors, Inc.*
Coal scales—*Richardson Scale Co.*
Automatic tripper—*Robbins Conveyors, Inc.*
Diesel electric locomotive—*General Electric Co.*
Carrimoor scraper and tractors—*Caterpillar Co.*

Ash-Handling System

Ash hoppers, ash sluicing, fly-ash collecting system and pyrites conveyors—*United Conveyors.*

Miscellaneous Equipment

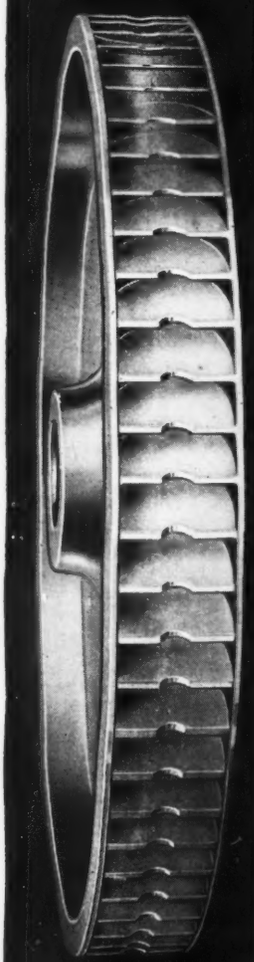
Piping—*Midwest Piping & Supply Co.*

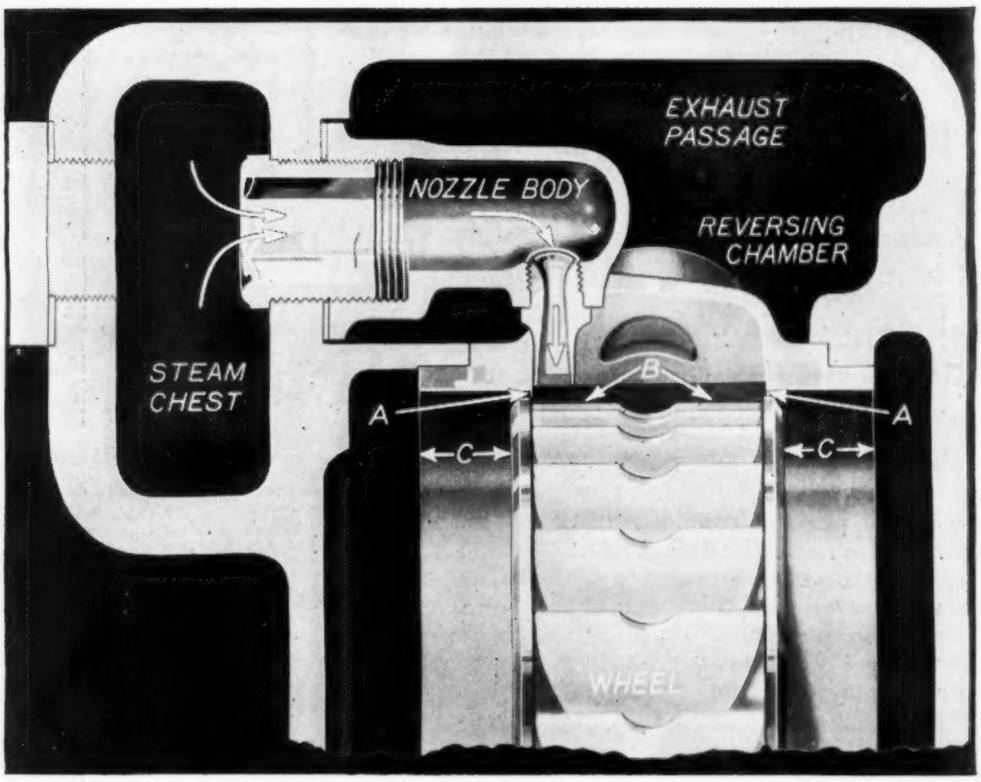
Hydrogen-cooling pumps, ash-sluice pumps, river-water service pumps, evaporator feed pumps and distilled water makeup pumps, all furnished by *Allis-Chalmers Mfg. Co.*

Diesel oil pumps by *Viking Pump Co.*; and fuel oil transfer pumps by *Worthington Pump & Machinery Corp.*

Air Compressors—*Worthington Pump & Machinery Corp.*
Combustion Control—*Leeds & Northrup.*
Gage Boards—*Leeds & Northrup.*
Feedwater Flow Control—*Bailey Meter Co.*
Cranes—*Whiting Corp.*
Elevator—*Montgomery Elevator Co.*

TERRY





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Large blade and rim clearances and extra large side clearance — one inch — help make Terry One-piece Wheel Turbines highly dependable in operation.

The blades cannot foul because of the protection afforded by the rims, which are not damaged, should rubbing occur.

Note the rim clearance, AA in diagram. Also the large blade clearance, B. Side clearance, CC, is so large that end-play from external thrust cannot damage wheel.

Terry Bulletin S-116 will give you full information on the Terry Wheel Turbine. A request on your business letterhead will bring you a copy.

T-1171

THE TERRY STEAM TURBINE COMPANY
TERRY SQUARE, HARTFORD, CONN.

A.S.M.E. Meets at Atlantic City

THE Sixty-Eighth Annual Meeting of the American Society of Mechanical Engineers, held at Atlantic City, December 1 to 5, had an attendance of 3100 and comprised some 200 technical papers in various branches of the field, as well as an attractive social program. Space here permits only a high-spot review of some of the papers and discussions of particular interest to power engineers.

Sub-Saturation Reheat Cycle

A paper suggesting a method of reheating within the low-pressure turbine was presented by **W. E. Caldwell,** mechanical plant engineer of the Consolidated Edison Company of New York.

Pointing out that the gain due to reheat takes place in the low-pressure turbine through an increase in available energy, a downward shift in the dew point and reduction in moisture in the subsequent stages, the author stated that with conventional reheating, a temperature of about 950 F at 400 psi represents the approximate economic limit in most cases for boiler gas reheat. This is largely because of the effect of increasing steam volume and pressure loss with diminishing pressure. Live steam reheating is attractive at low pressure for medium capacity plants, but for large capacities and high pressures the physical disadvantages outweigh thermal advantages.

The sub-saturation reheating suggested involves the use of bled steam from the higher turbine stages introduced into hollow stationary blades or nozzle partitions of the low-pressure turbine. The bled steam would enter the top of the diaphragm passage, flow through the hollow blades to the center segment, then into the lower half of the diaphragm, and on down through the lower blades to the bottom drains. The condensate would be discharged at the temperature corresponding to the heating steam pressure to re-enter the feed cycle. No external piping or apparatus would be necessary other than the condensate drain connections. Reheating in the last three stages would appear to be justified in most cases, although the number would be determined on the basis of economic considerations with initial steam conditions, turbine efficiency and cost as major influences. Efficiency would be increased by the addition of heating stages up stream until the dew point is reached.

In conclusion, Mr. Caldwell added that evaporative reheating releases the choice of initial steam pressure from the limitation imposed by initial temperature and offers more effective moisture control than by increasing the initial steam temperature. Also, the need for super alloys for very high temperature and for resisting water cutting is obviated, and operating simplicity is assured.

Discussion

This paper provoked considerable discussion in which several questioned whether, under the high steam velocity, the surfaces of the reheating blades would be sufficiently wetted to warrant the author's assumed heat transfer coefficient of 1100 Btu per sq ft per hr; also whether the whole surface would be effective. As one discussor expressed it: "The steam in the wet region is largely in a state of fog and it is doubtful if the mass of very fine droplets will completely contact the reheating walls; also the concave side of the passages will receive most of the larger droplets." Furthermore, if the surfaces become dirty the heat transfer would be further reduced.

The consensus was that the gain would be nearer to 1.5 per cent than 3.6 per cent as indicated by the paper. However, it was conceded that even the lower figure might be economically justified.

There appeared to be some difference of opinion as to the effectiveness of existing drainage devices; also experience varied as to the degree of maintenance attributable to erosion from water passing through the last wheels.

It was pointed out that the gain due the proposed reheat cycle would be less with a modern turbine than with the older Ratean design mentioned in the text. Several discussors expressed the opinion that the boiler reheat cycle offers the greater thermodynamic improvement.

In his closure, Mr. Caldwell stated that water has been observed to pour off the last-stage blades and that the chief cost of renewing blades that have been eroded from mositure lies in the outage and the necessary reserve capacity. His experience had indicated a life expectancy of the last-stage blades to be from 3 to 10 yr.

The New Sporn Station

Philip Sporn, president of American Gas & Electric Service Corporation and the American Gas & Electric Company, after reviewing the growth of the A. G. & E. System and discussing the influence of site, fuel, cycle and equipment on the economical generation of power, proceeded to describe design features of the new Philip Sporn Station and unit No. 5 at Twin Branch Station. Each of these will employ steam at 2000 psi, 1050 F and 1000 F reheat, the calculated net plant heat rate of the former being 9270 Btu per kwhr—a new record in steam-electric station performance.

Located on the Ohio River at the boundary of the Ohio Power Company and the Appalachian Electric Power Company (both part of the A. G. & E. System), the site of the Sporn station is adjacent to large coal reserves in both Ohio and West Virginia, and there is ample condensing water for at least three times the rated capacity of the present project.

There will be two units, each consisting of a 935,000-lb-per-hr boiler supplying steam at 2035 psig, 1050 F to a cross-compound turbine-generator consisting of a 3600-rpm, 35,000-kw high-pressure element and a combined 95,000-kw intermediate pressure element in tandem with a double-flow low-pressure section. Six stages of bleed heating are employed to achieve a final feedwater temperature of 441 F.

After passing through the high-pressure turbine, the steam will be exhausted at around 400 psi, and some 850,000 lb of steam per hr will be returned at 650 F to

the reheater where it will be raised to 1000 F. As finally adopted, the reheat cycle indicated an improvement of approximately 5 per cent in heat rate at an increase of about 2 per cent in first cost.

Five pulverizing mills (one a spare) will serve each boiler, and flue gases will be discharged from the Ljungstrom air heaters at around 235 F.

An attempt will be made to run without induced-draft fans. To do this the entire casing will be made tight for a furnace pressure of 15 in. of water. However, induced-draft fans will be installed for use in case the other arrangement is not successful.

A central control room, such as that which has proved so successful at Tidd Station, will be employed.

No. 5 unit at Twin Branch will be similar in most respects to one of the Sporn units.

The program of rated capacity additions, including a 100,000-kw addition to Tidd, will total 475,000 kw to be completed by July 1950.

Discussion

Discussion of this paper was confined mostly to a few questions, to one of which concerning unit cost, the author replied that the expected initial cost of the Sporn Station is in the neighborhood of $110 per kw, based on maximum rating and current labor costs. If the latter should increase the unit cost would also increase but probably not to exceed $117 per kw. He observed further that the Sporn and Twin Branch installations represent about as advanced design as is practical today; but this does not preclude new frontiers of tomorrow which must be explored.

With reference to load factor, he pointed out that the A. G. & E. System serves numerous small towns and efforts are being made to build up substantial industrial loads. A load factor of 68 per cent formed the basis of design. Concerning the desirability of a greater degree of standardization, as urged by one discussor, Mr. Sporn was of the opinion that standardization of cycles and steam conditions must precede that of equipment.

Heating Value of Fuels

The first of three papers on the symposium by **E. F. Fiock, R. S. Jessup** and **F. W. Fuegg** of the National Bureau of Standards, Washington, D. C., had to do with definitions.

The amount of heat liberated when a unit quantity of fuel is burned depends upon the conditions under which burning takes place; thus a complete definition should include these conditions.

The high heat of combustion of a solid or liquid fuel is given as the quantity of heat produced by the combustion of unit weight of the fuel in an enclosure of constant volume when the products of combustion, including liquid water, are cooled to the original temperature of the fuel. The low heat value of combustion is the quantity of heat produced by the combustion of unit weight of the fuel in air at a constant pressure of one atmosphere and at the initial temperature of the fuel when the products of combustion are cooled to the initial temperature of the fuel.

These two definitions may apply to gaseous fuels except that the high and low heats of combustion at constant pressure on a volume basis are generally given. The most important difference between the high and low values is that the water formed during combustion is condensed in the case of the high heat value and remains as a vapor in the case of the low heat value.

In power plant work the products of combustion are not cooled to the initial temperature and the water formed is not condensed, which would suggest use of the low heat value in calculating efficiency.

Since the power plant does not use all of the energy available, it is the fault of the plant and not the fuel. Therefore it seems logical to calculate plant efficiency on the basis of the total energy available in the fuel as indicated by its high heat value. As the methods of measuring heats of combustion are generally known, they will not be discussed here.

Professor **A. G. Christie** of Johns Hopkins University covered current definitions of thermal efficiency and uses of observed fuel heat values and consumption test data for the evaluation of thermal efficiencies reported for both steam and internal-combustion power plants. Thermal efficiency is given as the ratio of the output in equivalent Btu to the heat value of the fuel. This is expressed as a per cent in British and Continental practice, while in America and Canada it is expressed as "Btu per kilowatt-hour."

Tests to determine power plant performance in general conform with the A.S.M.E. Power Test Codes. The differences between heat values as determined by calorimetric measurements at constant pressure and at constant volume are discussed in the Code on Definitions and Values, 1945, Par. 134, "Heat Value." High heat value is generally used for solid and liquid fuels, but for gas when using the low heat value, efficiencies and heat ratio do not vary appreciably for wide ranges in the character of the gas. Low heat value is also used for flame temperature calculation.

As fuels are sold on the basis of high heat values, it is a strong argument for use of these values as standard for thermal efficiency determination. Furthermore, there is no more reason for neglecting the losses due to the latent heat of water vapor in the exhaust resulting from burning of hydrogen than there is to neglect the heat carried away by the condenser cooling water in figuring the overall efficiency of a steam cycle.

The difference between high and low heat values for the basic fuel is given as follows:

Bituminous coal	3 to 4 per cent
Oil fuels	6 to 7 per cent
Gas fuels	Up to 15 per cent

In the third part of the paper, **R. V. Kleinschmidt,** consulting engineer, discussed procedures for evaluating heating values based on thermodynamic properties of combustion gases. He stated that with the advent of the gas turbine, the problem of computing thermal efficiency and fuel required to cause a given temperature rise in the working fluid becomes more serious. There followed a brief review of the physical chemistry of the combustion process.

Beside the high and low heating values, he presented heating value at the working temperature which is a precise physical concept making the thermal efficiency of any heat engine independent of the nature of the fuel used.

Power Panel Dealing with Customer-Manufacturer Relations

A high spot of the meeting from the standpoint of power engineers was the Panel Discussion following the Power Luncheon on Wednesday. The program consisted of ten questions dealing with closer cooperation between equipment manufacturers and users to the end that better industrial power plants may result. The questions were submitted by industrial power men and the discussors were selected from among manufacturers.

The first question concerned steps involved in preparing a boiler proposal to meet customer requirements. This was answered by **W. S. Patterson,** of Combustion Engineering Co., who noted that too often the user has not made up his mind as to what he wants and expects the boiler manufacturer to prepare proposals on perhaps half a dozen alternates—all of which means time and money. Also, it is seldom that enough drawings are supplied with the specifications and lack of space is often a handicap.

Among the factors to be considered after analyzing the specifications are building limitations, capacity and range, steam conditions, steam temperature control range, character and temperature of feedwater, fuel analysis, desired efficiency, various evaluations for auxiliary power, draft loss, building space, etc., and customer preference. Calculations based on these data involve figuring the heat supplied by the fuel; that supplied by the feedwater; and that in the steam; as well as gas weights, heat transfer, etc. A change in any of the items listed means another set of calculations, hence the undesirability of too many alternates.

The second question, submitted by **L. A. Darling,** suggested that lower equipment costs might be possible if customers were to tell manufacturers precisely what conditions would be encountered and what results would be required, but left the specifications open so that the manufacturer would have wide latitude in what to offer.

The first discussor was **Martin Frisch,** of Foster Wheeler Corp., who conceded that broad specifications might lead to low initial cost, but believed that the user would not be well served. He favored detailed specifications prepared by a competent individual familiar with the exact conditions to be met. This permits proposals from several manufacturers to be compared on the same level. It does not preclude a manufacturer offering a standard unit at some saving to the purchaser, but he should point out clearly all departures from the specifications and enable the user to determine whether such savings in first cost would be economical over a long period.

D. S. Walker, of Combustion Engineering Co., the second discussor, gave an affirmative answer to this question as concerns small units, such as the package-type boiler. As we go up in capacity, he said, it is still possible to adhere to certain standards by employing increased furnace widths and give the user the benefit of savings in engineering. But where special conditions are to be met (characterized as a "shoehorn job") the user must expect to pay the additional cost. He suggested that items not produced by the boiler manufacturer be purchased separately, if the user has an engineering department or a consulting engineer, as one means of securing lower boiler prices.

As to standardization, Mr. Walker believed this possible to a considerable degree by individual boiler companies, but not among different companies.

The next question, which was also proposed by Mr. Darling, asked how much equipment manufacturers should be expected to know about the effects of their designs upon the cost of other things which they do not furnish.

D. W. R. Morgan, of Westinghouse Electric Corp., in answering this, was of the opinion that the turbine manufacturers do have a good idea as to the effect of their designs on such costs, but that they seldom receive from customers sufficient information to enable them to assist and guide the general application of turbines and their equipment in the industrial power plant. The equipment manufacturer, he said, can and should do more to help the industrial power plant user; but, on the other hand, the user should show a more sympathetic attitude toward standardization. The manufacturer is obliged to spend too much time working up performance under many conditions, which time might better be devoted to development and improvements that would reflect in lower costs and better equipment.

Question 4, proposed by **L. M. Goldsmith,** asked when equipment manufacturers will make it a practice to inquire as to performance of equipment after a year's operation, or when guarantees have expired.

Commenting on this question, **L. E. Newman,** of General Electric Co., suggested that two tests be applied: (1) that the writing of specifications be approached on the basis of what the equipment will do for the user rather than how it should be built; and (2) call for performance checks or tests capable of unbiased proof. Good tests are hard to get and poor tests may be worthless.

A. E. Raynor, of Babcock & Wilcox Co., was of the opinion that reputable manufacturers endeavor to keep in touch with equipment performance through the years and would not think of offering duplicates of a unit that had shown deficiencies.

H. C. Stevenson, of Ingersoll-Rand Co., considered it good policy for the manufacturers' service engineers to keep contact with equipment after installation and that users' suggestions should be given careful consideration.

Question 5, offered by **J. Campbell, Jr.,** dealt with the handling of tests.

The first discussor, **C. B. Campbell,** of Westinghouse Electric Corp., said that the turbine manufacturer is largely dependent on shop tests, as there are seldom ideal conditions for conducting tests in industrial plants. Component testing is important from the design standpoint. Although a field test may be influenced by some favorable station factor, it can serve as a valuable guide and many more reliable field tests would be welcome. Any deviations from the A.S.M.E. Test Code should be by mutual agreement between the user and the manufacturer and the latter's representative should not only be present but participate.

The second discussor, **W. H. Rowand,** of Babcock & Wilcox Co., referring to boilers, reviewed three classes of tests, namely: (1) those to determine if equipment meets guarantees; (2) tests by the owner to establish operating goals; and (3) tests desired by the manufacturer for design and development purposes. The

last-mentioned, although the responsibility of the manufacturer, also deserves the cooperation of the user.

Question 6, by **S. B. Roberts,** inquired whether manufacturers have formulated relationships between furnace volume and surface for different types of boilers and whether they have developed standards for the estimation of furnace surfaces with different kinds of tubes, using commercial cleanliness factors.

Replying to this, **Ollison Craig,** of Riley Stoker Corp., stated that such standards as heat release per square foot of grate surface, heat release per cubic foot of furnace volume, and per square foot of wall surface are fundamental. It is not usual to put in as large a furnace for high-fusion coal as for low-fusion coal. Moreover, since the gas temperature varies throughout the furnace, it is necessary to work with averages. As to heat-absorbing relationships for different types of furnace walls, he pointed to lack of agreement among manufacturers, although individual boiler manufacturers have developed certain standards for their own use.

Question 7, submitted by **W. T. Sherman,** inquired as to why boiler manufacturers rate performance on 15 per cent excess air and clean boiler surfaces, when the customer is interested in commercial performance over at least three-month periods.

This was answered first by **G. E. Anderson,** of Foster Wheeler Corp., who suggested Mr. Sherman was referring specifically to oil-fired jobs, as it is generally recognized that excess air will range from 10 per cent with natural gas up to as high as 30 or 35 per cent with certain types of stokers. It is not customary, he said, to employ data that can be obtained only with clean surfaces, and anticipated performance is usually based on data obtained in actual use. This latter statement was affirmed by **D. S. Walker** of Combustion Engineering Co.

Question 8, offered by **R. F. Hanson,** indicated a tendency on the part of manufacturers to give insufficient attention to field engineering and adjustment service.

In reply, **J. W. Anne,** of Elliott Co., considered it most desirable that men who service equipment after installation be experienced, but during the war service staffs suffered and manufacturers are now trying to again build up their field service personnel through training courses.

Question 9, by **A. L. Glaeser,** inquired why manufacturers of auxiliary equipment do not place complete data on their submitted prints of apparatus, such as duty, weight, etc.

This was answered by **L. D. Whitescarver,** of General Electric Co., who pointed out that there are two classes of drawings—preliminary and standard. The former contain approximate information, whereas the latter should contain full information as to weights, dimensions, etc.

Stephen Bencze, of Elliott Co., added that all members of the N.E.M.A. have agreed to provide a standard outline form as concerns dimensions, plan views, etc., particularly those applying to turbine drive. This does not apply to tailor-made jobs which involve many modifications.

Question 10, submitted by **J. Campbell, Jr.,** inquired as to basic research being carried on by manufacturers of power equipment.

The answer by **Paul Diserens,** of Worthington Pump and Machinery Corp., was that power equipment manufacturers are concerned more with applied research and engineering development in its broadest aspects rather than in fundamental research such as carried out by the chemical industry which Mr. Campbell had in mind. If time permitted, more manufacturers would undoubtedly develop information first and build afterwards.

L. V. Armstrong, of Ingersoll-Rand Co., also commented that most diesel engine builders are actively engaged in basic research problems. These concern improved combustion, increase in the range of permissible fuels, extending the life of wearing parts, heat transfer, water treatment, and elimination of noise, smoke, vibration and other nuisance factors.

Furnaces for By-Product Fuels

Otto de Lorenzi, of Combustion Engineering Company, presented a paper on this subject together with color motion pictures of furnaces in which various so-called waste fuels were being burned. He discussed the most commonly used by-product fuels and related methods of firing and some of the difficulties experienced.

The most widely available substitute fuels are found in petroleum refineries, steel mills, coke plants and in the pulp and paper, lumber and sugar industries.

Oil Refinery By-Product Fuels—The solid fuels are asphaltic pitch, a residue, which when heated has properties similar to heavy bunker C oil; and petroleum coke which, for best results, is pulverized and burned in water-cooled furnaces.

The liquid fuels often have a high specific gravity and contain varying amounts of solid matter in suspension. The most widely available but frequently most troublesome because of its varying characteristics and high sulphur content is acid sludge. Its gravity ranges between 5 and 14 A.P.I. and its viscosity is indeterminate. Due to suspended solid matter large orifices in the atomizer must be used and therefore ignition is not stable. Generally sludge is burned in combination with other more stable fuels.

The most common gaseous by-product is refinery gas. Although having a higher heating value than natural gas and of varying composition, it can be handled in burners similar to those for natural gas. Furnace design limitations are the same as for natural-gas firing.

Steel Mill By-Product Fuels—Blast furnace gas has a heating value of 90 to 110 Btu per cu ft and contains considerable dust of a high, iron-oxide content. Selection of burners and type of furnace are dependent on the degree to which it is economically desirable to clean the gas. This gas is slow to ignite; therefore, preheated air and thorough mixing at the burner are essential.

Coke breeze is the finest obtained in the manufacture of metallurgical and domestic coke. This fuel is difficult to ignite due to its sponge-like structure and low volatile content. The traveling- or chain-grate stoker with arch setting provides the most successful means of burning the fuel.

By-Product Fuels from Lumber Industry—As much as 50 per cent of the timber used may become

waste. Sawdust and shavings need no processing. Other waste portions are reduced in size and become "hog fuel." Because of high-moisture content, usually 40 to 55 per cent, combustion requires three stages: preliminary drying, distillation and burning of volatile matter and burning of residual fixed carbon. The most simple furnace arrangements provide a dutch oven for drying and gasification and a secondary furnace in which combustion is completed. The use of refractory arches and walls in the primary furnace provide the maximum heat for maintaining gasification. Fuel is supplied through openings in the arch and burns in cone-shaped piles with from 30 to 40 per cent excess air.

PAPER MILL BY-PRODUCT FUELS—These fuels fall in two classifications: wood-room refuse in the form of wet bark, sawdust, ground wood screen tailings and butt ends; and black liquor. Bark may contain up to 80 per cent moisture and requires some drying before burning. The dutch-oven type furnace employing flat grates is used most widely.

Black liquor is the residue left after removal and washing of wood pulp following its preparation. The dissolved solids contain about 50 per cent carbonaceous matter, the remainder being the chemical used in the cooking process. The black liquor is prepared for burning by reducing its moisture content to about 30 to 35 per cent. In order to replace the sodium salts that are lost in the process, salt-cake or Na_2SO_4 is added to the black liquor before it is burned. This liquor is sprayed into a water-cooled furnace where complete drying and combustion take place The chemical is melted out into a tank of water to form "green" liquor. A reducing atmosphere must be maintained in the furnace bottom to aid in reduction of the salt cake to sodium sulphide.

BY-PRODUCT FUEL FROM SUGAR MANUFACTURE—Bagasse, or cane trash, is the refuse remaining after the juice is extracted from the sugar cane. It is a fibrous material with an analysis similar to wood and contains from 40 to 60 per cent moisture. The amount of this fuel available will provide all the steam requirements in the production of raw sugar. Bagasse is generally burned like hog fuel in dutch-oven type furnaces on horse-show-shaped hearths, or on inclined grates. The ash produces a slag that causes a difficult removal problem.

Burning Pulverized Coal Under Pressure

Herbert R. Hazard, Locomotive Development Committee, presented a paper prepared jointly with **Fred D. Buckley,** Battelle Memorial Institute, entitled "Experimental Combustion of Pulverized Coal at Atmospheric and Elevated Pressures." Reported was a study of the effect of pressure on combustion reaction and tests made with four small air-cooled combustors operated at high heat-release rates and low pressures in connection with a small gas-turbine unit.

The furnace for the pressure tests was tubular, water jacketed and lined with carborundum. Three different burners, differing in dimensions to give equal burner-tip velocities for equal firing rates at pressures of 3, 30 and 60 psi were used. Air and coal were premixed.

Regulation of furnace pressure proved difficult because of pressure fluctuations caused by changing ash conditions and surges in the coal feed. By use of a high-volatile, low-ash, high-fusion temperature coal, ignition and slagging difficulties were minimized. Ignition and flame stability were improved by preheated air.

Varying excess air had no determined effect on the reaction rate. Data from the pressure furnace were plotted in two forms: percentage of combustible burned against distance from the burner and percentage of combustible burned against particle residence time.

It was concluded that the combustion reactions are not affected measurably by pressure up to 75 psi or by air preheat up to 600 F. The results of these tests bore out the findings of others.

A study of coal-burning gas-turbine combustors was undertaken concurrently with the above tests. Those which seem to merit study were the balanced-vortex combustor and the various tubular designs. An aircraft turbo-supercharger provided the open-cycle gas turbine.

The balanced-vortex combustor consists of a squat cylinder in which air enters tangentially through vanes around the periphery. Pulverized coal is injected into the vortex thus formed. This design is better adapted to the burning of coarser pulverized coal than the tubular type combustors.

Discussion

One discussor said that the action of ash on turbine blades depends on gas temperature, angle of impingement, relative velocity and size of the particles. If the ash particles are fine enough, one need not worry about erosion.

Another mentioned that in burning pulverized coal under pressure the critical factor is the rate of heating the coal particle just before ignition.

Synthetic Liquid Fuels

According to **Dr. W. C. Schroeder,** of the U. S. Bureau of Mines, our domestic crude oil production of nearly 5,100,000 bbl daily is barely sufficient to meet the country's current needs, and it is probable that the demand will steadily increase to a predicted consumption of at least 6 million by 1951.

While there is a known reserve of about 21 billion barrels, plus a small net import, the prospects of increasing the reserves in the United States are not bright, as discoveries of new oil pools have failed to match consumption for the past 8 or 9 years. Further efforts to this end include drillings on the Continental Shelf and the reworking of old fields that have been exhausted by ordinary pumping methods. The extent to which such work may be carried will depend upon the cost of recovery as compared to that of producing oil from other sources, particularly synthetic production from gas, coal or shale.

Touching upon the importation of foreign oil, Mr. Schroeder pointed out that until 1947 the United States had been a net exporter of petroleum on a large scale, but that during the first six months of the present year the country showed a small import balance. However, foreign consumption increased about 13 per cent during 1946, compared to 1941; and industrialized nations,

such as England and France, are finding it difficult to meet their energy requirements with coal, hence are turning to oil. If this trend continues and increases, the proportion of the world's oil available to the United States may diminish greatly. There is also the strategic problem of allowing any large portion of this country's needed supply of oil to rest in distant foreign lands which might be vulnerable to seizure or attack.

Synthetic Processes

The speaker described the Fischer-Tropsch process of producing oil from natural gas, or from coal, as was so largely employed by the Germans during the late war, and told of the recent development of new catalysts to improve production by this method.

The location of synthetic liquid fuel will depend largely on the presence of vast quantities of the raw materials—natural gas, coal and oil shale. While the proved natural gas reserves of the United States are about 150 trillion cubic feet, that available in many sections is already committed to pipe line transportation for industrial and domestic use; or the volume available in many localities would not be sufficient to warrant an oil recovery plant. However, along the Gulf Coast and in southwest Texas, where present pipeline demand is small, there is an estimated 40 trillion cubic feet of idle gas, much of which might be available for conversion to liquid fuel. This might be supplemented by other regions to a total of 50 trillion cubic feet corresponding to a yield of 4 to 5 billion barrels. Since the initial investment in such plants would be high, they should be amortized over long periods.

The carbon monoxide and hydrogen used for the Fischer-Tropsch synthesis can be made from coal as well as from natural gas. In Germany the practice was to make coke from coal and then gasify the coke in water-gas machines; but this has several disadvantages from the standpoint of high initial investment and the requirement of a coking coal. Gasification of a non-coking coal with oxygen and steam would involve pressure.

The Lurgi process does not operate under pressure but does require a sized fuel, and produces considerable quantities of methane.

The hydrogenation process is well adapted to the production of aviation gasoline from coal and is the only large-scale synthetic process at present which will give a base stock for 100-octane gasoline with good rich-mixture performance. However, it does not produce as good a diesel oil and as cheap a motor gasoline as the Fischer-Tropsch process.

On the basis of present knowledge, oil shale can be refined to yield industrial fuel oil and diesel fuel with a cetane rating between 35 and 45; but it cannot be looked upon as good motor fuel stock, for it yields a low-octane gasoline (50 or 60).

Mr. Schroeder reviewed the development work with pilot plants now being carried out by the Bureau of Mines under the Synthetic Liquid Fuels Act of 1944 and predicted that production costs would run from 3 to 5 cents a gallon higher than present prices of products from natural petroleum. He also told of the underground coal gasification experiments at Gorgas, Ala., which have been previously described in COMBUSTION.

Nuclear Energy

Speaking at the Tuesday Luncheon, **David E. Lilienthal,** chairman of the U. S. Atomic Energy Commission, revealed the philosophy underlying the policy of the Commission, as trustees for the American people, in dealing with this most important matter.

Many people believe, he said, that secrecy is synonymous with security; but secrecy improperly applied can weaken security by hobbling development. Not that it would be wise to release all information at the present time, in view of international conditions; but as a long-range policy the Committee recognizes that new ideas result from competition with unrestricted basic information and the fertilization of many minds. Research at various universities is being fostered and the training of scientists and engineers in this field is being encouraged.

The nation has already expended about 2½ billion dollars on atomic energy development; but many improvements over the plants at Oak Ridge and Hanford are indicated, and with the vast research program and extension of facilities that are now under way, it is likely that this expenditure will double within a few years.

With reference to nuclear power plants, he cautioned that many problems would have to be solved before they would be commercially possible, but it was his belief that ultimately the development of useful power from nuclear fuels could become a great asset to this country.

On view during the week was an atomic energy exhibit, developed for the Atomic Energy Commission by the Brookhaven National Laboratories. This included an atomic power plant demonstration shown by special lighting effects.

At the Tuesday afternoon session following Mr. Lilienthal's luncheon talk, **Dr. John R. Huffman** of the Clinton laboratories at Oak Ridge gave a paper entitled "Nuclear Engineering—Basic Design Background." In this he pointed out new concepts and certain unique features that characterize the field of nuclear engineering and discussed the role of the engineer in that field. With reference to the latter, his remarks were in part as follows:

"Engineers played a very prominent role in conjunction with the physicists and the chemists during the war effort to produce the atomic bomb, and from this effort has developed a new niche in many fields of engineering—nuclear engineering. As is true of any new specialization, this field first draws its basic principles from the fundamental sciences and from the older branches of engineering.

"In the first analysis, nuclear engineering is not particularly interested in nuclear power. As long as this power has to be obtained through the path of heat, which is the case in the present state of scientific knowledge, there are plenty of engineers well versed in power plants, turbines and the like, to design the power machinery. The duty of the nuclear engineer, in so far as he is a specialist, could end therefore with the method of producing the desired temperature level in a satisfactory heat-transfer medium. He cannot, how-

ever, turn over the entire responsibility to power engineers because of the hazards of radio activity in this field. Shielding, remote control and waste disposal will always remain in the picture. The nuclear engineer will become more interested in power production itself when and if science evolves methods of usefully releasing nuclear energy by means which do not involve the heat cycle.

"For the most efficient work in this field, engineers must become familiar with certain phases of physics. Young men who are interested should obtain elementary training in nuclear physics, more training in mathematics, and an understanding of radio-chemical techniques. Mechanical engineers should by all means obtain some training in chemistry. . . . To develop a strong group of engineers in this field will take considerable time; and during the interim, the nuclear engineer must be able to interpret a new set of values to other engineers."

Flash Drying

Charles W. Gordon, Manager, Flash Dryer Div., Combustion Engineering Company, presented a paper describing flash drying of materials by instantaneous removal of moisture from materials by the application of heat in a turbulent stream of hot air. Because of the complex nature of the drying of materials in industry, many different types of dryers have been developed. C-E Raymond systems, known as "Flash Drying Systems," are designed to operate under three distinct conditions, namely drying without disintegration, drying with disintegration and drying and pulverizing. The first two systems may be single stage, multi-stage or counter-flow while the latter may be single or multi-stage.

The C-E Raymond Flash Drying and Incineration System was originally developed for the drying of sewage sludge for fertilizer or for incineration. This system is equally applicable to many industrial wastes, an example being furfural waste resulting from the treatment of corn cobs, oat hulls, cotton seed hulls and the like which produce a valuable fertilizer. Other examples are wood waste and coffee grounds. In cases where the incineration of wastes produces heat in excess of that required for complete drying, these wastes may be used as fuel for steam generation.

Flash Drying has been defined as the practically instantaneous removal of moisture. Depending on design requirements, the material is in contact with the drying air from one to ten seconds. The operation is substantially adiabatic.

The fundamental factors which govern moisture evaporation by heat are: moisture dispersion, temperature differential, agitation and particle size. In the case of the latter it may be necessary to grind and dry certain substances simultaneously. Still others require only surface drying and the particles may be relatively large such as coal of $^1/_4 \times 0$ size. Flash Drying will remove not only surface moisture but that which is absorbed; in fact, bone dryness can be obtained with many materials by multi-stage drying.

Flash Drying systems are simple in design and not difficult to operate. They handle only a few pounds of material at a time with resulting safety. The principal parts are: the air heater; the wet feeder; the mixer, which mixes previously dried material with increasing wet feed so that the material can be more readily picked up by the hot air stream; the agitator; the collection system, which receives the material from the agitator and separates it from the evaporated moisture and spent air; the dry divider, which automatically returns the necessary amount of previously dried material to the mixer; and the cooling and transport system which receives the finished product and simultaneously conveys and cools it in an air stream.

An example of drying without disintegration is the handling of wet coal $^3/_8$ in. and under in size. Surface moisture of 8 to 12 per cent is usually reduced to 2 to 3 per cent.[1] For ultra fine and very wet coals an alternate system employs a "dry return" to aid in more complete drying.

Expanded Tube Joints

A paper by **G. Sachs** covered a mathematical treatise on the tightness of expanded tube joints based on a research project conducted at the Case Institute of Technology in cooperation with the Office of Naval Research, Washington, D. C. The influence of tube dimensions and varying yield strengths of the tube and plate material are considered and equations are obtained for the residual stresses, which can be adapted to numerous conditions.

A measure of tightness will be the residual pressure between tube and plate. This tightness becomes a maximum at certain ratios of outside to inside diameter of the tube; when tube and plate are of the same material the ratio is 1.4, but when the tube material is stronger the ratio may be as high as 1.65.

Forced Circulation Boiling of Water

A heat transfer paper of interest to boiler designers was "Prediction of Pressure Drop During Forced-Circulation Boiling of Water," by **R. C. Martinelli** of the University of California and **D. B. Nelson** of the General Electric Company. The authors propose a tentative method for the rapid calculation of this pressure drop. The paper combines the data obtained from previous work on this subject and establishes a new approach to the problem. The method proposed is based on a number of hypotheses; is an extrapolation of existing data and will require experimental verification. The authors hope the paper will stimulate further investigation of the problem.

The application of pressure drop data obtained during the isothermal flow of air and various liquids to the evaluation of local pressure gradients during forced-circulation boiling proved the basis for this new method. Curves have been developed by which the pressure drop during boiling can quickly be estimated once the exit quality, boiling pressure and pressure drop for 100 per cent liquid are known.

It was pointed out that the pressure drop resulting from the flow of a boiling mixture, when the pressure drop across the tube is small compared to the absolute pressure, is made up of two parts: (1) the pressure drop

[1] One installation using river coal reduces a moisture of 20 to 25 per cent to about 5 per cent.

(*Continued on page 54*)

Removal of Silica Deposits from Steam Turbines by Caustic Soda

By I. B. DICK

Consolidated Edison Co. of New York, Inc.

The following is from a paper before the recent Eighth Annual Water Conference at Pittsburgh, under the auspices of the Engineers' Society of Western Pennsylvania. It details the procedure employed by the Consolidated Edison Company of New York over the past four years in the use of caustic soda to remove silica deposits from turbine blades for the restoration of rated capacity. Certain necessary precautions are stressed and it is pointed out that each machine constitutes a separate problem that must be studied individually.

THE writer's experience with removal of water-insoluble deposits from turbine blades by washing with caustic soda extends to three stations, each representing a combined high- and low-pressure operation. High pressures involved range from 900 psi to 1800 psig and, in each case, the high-pressure steam is topped in a topping turbine before going to the condensing turbines.

The most aggravated case of silica fouling is in the Waterside Station, where loss of 5 per cent in condensing turbine capacity per month has been experienced. Makeup water, which is softened in a combination sodium-hydrogen ZeoKarb plant, may amount to 40 per cent of the total station evaporation. It normally enters the system through two turbine condensers and through a direct contact sub-atmospheric heater, mixes with condensate from four other condensing turbines, and is deaerated in four atmospheric deaerating heaters before entering the eight high-pressure boilers. Caustic soda is introduced at the outlet of the deaerating heaters and disodium phosphate is admitted directly to each boiler drum. Total dissolved solids on six of the boilers are limited to 500 ppm, and the other two boilers generally are restricted to 600 ppm. With the high percentage of makeup, this requires about 4 per cent blowdown. Raw water is New York City Croton supply. Approximate analyses of the raw water and of softened water are given in Table 1. With 40 per cent makeup, silica in the feedwater will average about 6 ppm.

TABLE I—APPROXIMATE COMPOSITION OF RAW (CROTON) AND SOFTENED (ZEOKARB) WATERS, WATERSIDE STATION

	Croton, ppm	ZeoKarb* Effluent, ppm
SiO_2	6.3	6.3
Fe	0.2	0.3
Ca	13.0	
Mg	4.5	
Na	3.3 }	20.4
K	1.3 }	
CO_3	0.0	
HCO_3	42.0	6.4
SO_4	17.0	14.4
Cl_2	4.0	29.2
NO_3	1.3	0.8
Hardness	50.0	0.0
Total solids (by summation)	92.9	77.8

* 44 per cent of flow through Na units, 56 per cent of flow through H_2 units.

The high-pressure (approximately 1400 psig drum pressure) steam from each pair of boilers goes to one topping turbine, exhausting at 200 psig. This 200-psi steam may go four ways:

1. To six condensing turbines.
2. To the street for district steam heating.
3. To feedwater heaters.
4. To feed-heating turbines mounted on the same shaft as the topping turbines and exhausting into a 5-psig header supplying steam to the deaerating heaters.

Steam quality from the boilers generally runs about 500,000 ohms, not degassed, and from 1,000,000 to 1,500,000 ohms, degassed in Straub degassing condensers. Silica content of this steam by the method of Straub and Grabowski ranges from about 0.1 to 0.4 ppm and averages about 0.2 ppm. We are unable to correlate plant data with the extreme variations in silica content of steam or to offer satisfactory explanation for them. Boiler water generally will run about 25 ppm silica.

Tables 2 and 3 show the location and analyses of typical turbine-blade deposits.

The six condensing turbines in this station are each caustic washed about every two months. The feed-heating turbines also are caustic washed but at somewhat lesser frequency. The topping turbines, with the exception of one unit for a short time, do not lay down insoluble silica deposits and so are not caustic washed.

The removal of silica deposits form turbine blades by caustic soda is, of course, a chemical reaction. Important among the controlling factors are temperature, concentration and time. Silica deposited on turbine blades will not dissolve in caustic soda solutions at atmospheric pressure and normal boiling temperature. However, in a turbine at elevated temperatures, it reacts quite rapidly. Concentration of caustic soda solutions will be adjusted automatically in a hot turbine by evaporation of excess water until the boiling point of the resultant solution is the temperature of the turbine. We have had samples from bleed points during a caustic wash as high as 600,000 ppm NaOH, or 60 per cent solution when injecting a 20 per cent solution at the throttle. Time of contact is under the control of the operator, as will be explained.

Steps in Washing Process

The turbine to be washed should be at operating temperature at the start of the process. If it has been out of service and has cooled down, it should be brought back

TABLE 2—40,000-KW MACHINE

Stage Throttle	Pressure, Psi Abs	Temp., F	Rotating Blades: Character of Deposits	Rotating Blades: Analyses of Deposits, Per Cent: Quartz	Cristobalite	Amorphous Silica	Ferric Oxide	Calcium Carbonate	Lead Oxide	Remarks	Diaphragm: Character of Deposits	Diaphragm: Analyses of Deposits, Per Cent: Quartz	Cristobalite	Amorphous Silica	Ferric Oxide	Calcium Carbonate	Lead Oxide	Remarks
1st step	200	500	Brown, paper thin	70–80	...	..	5–10	10–20	..	...	.....	...	...	...	...	..	...	..
1st	120	487	.....	...	...	..	...	...	..	...	Brown	...	...	90–95	5–10	..	...	..
2nd step			Grayish white, paper thin	70–80	...	..	5–10	10–20	..	*	.....	...	...	...	...	..	...	..
2nd	93	439	Not reported	70–80	...	..	5–10	10–20	..	...	Brown	...	...	90–95	5–10	..	...	..
3rd	71	392	Small amount, white, paper thin	90–95	...	..	5–10	...	..	...	Brown, metallic, very adherent	90–95	...	...	5–10	..	...	..
4th	53	343	Small amount, white, paper thin	...	90–95	..	5–10	...	..	...	Gray, hard, very adherent	90–95	2–3	...	5–10	..	...	..
5th	39	291	Brown, paper thin	...	70–80	..	20–30	...	..	...	Brown	1	...	...	10–15	..	80–90	..
6th	28	246	Brown, paper thin	...	70–80	..	5–10	...	..	*, †	Brown	...	...	...	90–95	..	...	*
7th	19	224	Black scale, paper thin, removed as powder	...	70–80	..	5–10	...	..	*, †	Light brown	...	85–95	2–5	5–10	..	...	..
8th	12	201	Black scale, paper thin, removed as powder	...	70–80	..	20–30	...	..	...	Dark brown, hard, very adherent	...	...	70–80	20–30	..	...	..
9th	5.5	166	Could not be inspected; being removed	...	...	..	...	...	..	...	Not reported	...	...	...	...	..	...	..
10th	2.5	135	Not reported	...	...	..	...	...	..	...	Not reported	...	...	...	...	..	...	..
11th	0.5	79	Not reported	...	...	..	...	...	..	...	Not reported	...	...	...	...	..	...	..

* Total weight of sample was less than 1 mg; probably not representative.
† Sample contains 10–20 per cent material not identified because of small weight of sample.

to temperature by operating in a normal manner on full-line pressure superheated steam until a condition of temperature equilibrium is reached. The speed of the machine then should be reduced to the lowest value practicable, using superheated steam at full pressure and stabilized. A speed of 300 rpm probably will be found satisfactory in most cases. The low speed is believed desirable to prevent the caustic soda solution from being thrown out toward the tips of the blades, thereby cleaning only the tips but not the base. The primary valves should be maintained fully open by any suitable means, and any subsequent valves should be closed. Turbine speed must be controlled by manual adjustment of steam supply and by manipulation of condenser vacuum.

Caustic soda solution of predetermined strength, possibly 10 per cent by weight, then should be injected directly into the steam to the turbine in such a manner that it will be carried into the machine. A positive displacement pump of proper capacity is convenient to use, delivering the solution directly into the flow of steam in the valve chest or other convenient point ahead of the primary nozzles. A small gear pump of 3–6 gpm capacity, driven by a fractional-horsepower electric motor, is convenient, economical and readily portable, and can be plugged into convenient outlets as needed. Check should be made to insure that the caustic soda solution will not be unintentionally drained from the machine through open casing drains or through bleed connections ahead of the turbine exhaust.

Caustic soda will burn the skin very rapidly and will attack all animal fibers such as wool and leather. Goggles and rubber garments must be provided. Large buckets of saturated boric acid solution should be available and must be used copiously whenever caustic soda gets

TABLE 3—35,000-KW MACHINE

Stage	Pressure, Psi Abs.	Temp., F	Character of Deposits on Diaphragm	Character of Deposits on Rotating Blades	Petrographic Analyses of Deposits on Rotating Blades, Per Cent: Quartz	Cristobalite	Amorphous Silica	Magnetic Ferric Oxide	Magnetic Iron Oxide	Calcium Sodium Iron	Calcium Carbonate	Sodium Carbonate	Caustic Soda	Remarks
1st	205	510	.....	Tan, paper thin	2–3	40–50	35–45	5–10	...	1	1	...	...	.....
2nd	190	498	None—metal clean	Tan, paper thin	1–2	30–40	35–45	5–10	...	1	10–20	...	...	.....
3rd	176	482	None—metal clean	Small amount, dark brown, paper thin	...	...	...	60–70	...	15–25	10–20	...	...	.....
4th	162	470	None—metal clean	Small amount, dark brown, paper thin	...	...	...	20–30	...	60–70	5–10	...	...	.....
5th	146	450	None—metal clean	Small amount, dark brown, paper thin	Trace	...	...	25–35	...	65–75	...	...	...	.....
6th	130	432	None—metal clean	Small amount, dark brown, paper thin	...	...	...	...	...	...	...	...	...	.....
7th	114	414	None—metal clean	Tan, paper thin	80–90	...	...	5–10	...	3–5	3–5	...	...	.....
8th	98	386	Tan, paper thin	Tan, paper thin	55–65	...	...	5–10	...	1–2	25–35	...	...	.....
9th	81	360	Gray, paper thin	Small amount, tan, paper thin	50–60	...	...	5–10	...	1–2	35–45	...	...	.....
10th	66	340	Gray, paper thin	Small amount, tan, paper thin	Trace	60–70	...	10–20	...	5–10	10–20	...	...	.....
11th	52	292	Gray, paper thin	Small amount, tan, paper thin	...	...	...	...	...	...	...	...	...	Samples too small for analysis
12th	40	266	Gray, paper thin	Small amount, tan, paper thin	...	...	...	...	...	...	...	...	...	Samples too small for analysis
13th	29	249	Gray, paper thin	Small amount, tan, paper thin	...	...	...	...	...	...	...	...	...	.....
14th	21	230	Gray, paper thin	Gray, paper thin	1–3	...	...	10–20	65–75	5–10	3–5	...	...	.....
15th	14	210	Gray, paper thin	None—metal clean	...	...	...	...	...	...	...	...	...	.....
16th	9	189	None—metal clean	None—metal clean	...	...	...	...	...	...	...	...	...	.....
17th	5	165	None—metal clean	None—metal clean, tiny pits	...	...	...	...	...	...	...	...	...	.....
18th	3	139	Scale, readily flaked off	None—metal clean, tiny pits	...	...	...	30–40	60–70	...	...	...	...	Scale on diaphragm
19th	1	108	None—edge of blades eroded	Not reported	...	...	...	...	...	...	...	...	...	.....
20th	0.5	79	Not reported	Not reported	...	...	...	...	...	...	...	...	...	.....
					...	...	...	3–5	5–10	...	5–10	75–80	1–2	Deposit on spindle

on the body or clothing. Sand is convenient to soak up any spillage on floors and should be used promptly because caustic soda solutions are very slippery and are hazardous under foot.

At the beginning of a wash, caustic injection should continue until heavy concentrations of the chemical appear at the turbine exhaust. As such concentrations are not desired in boiler feedwater, condensate during the wash must be overboarded. If the turbine is not condensing, provisions must be made for disposing of the exhaust steam outside the system. Sprays in the exhaust line have been used to condense exhaust steam from noncondensing units and adequate drain connections then permit the condensate plus condensing water to be overboarded. In this case, only fresh water should be used for condensing. About 30 min. generally is sufficient for the caustic soda to reach the turbine exhaust in quantity. In condensing units, tests of hotwell water may show concentrations of caustic soda of several thousand parts per million and casing drains, if sampled, may run up to 300,000 ppm.

When the concentration of NaOH has reached a high level in the hotwell or turbine exhaust and has stabilized, a time interval should be allowed for the chemical reactions to take place. Steam and caustic soda should be shut off and the caustic soda injection lines should be flushed into the turbine with a minimum quantity of fresh water to prevent plugging of the injection "nozzle" from evaporation of water from the caustic soda solution.

The machine should be allowed to come to rest or to turn on the turning gear. This is called the "soaking" period. About 15 min. should be sufficient in most cases. Then the steam should be turned on again and the speed adjusted as before, to perhaps 300 rpm. Caustic soda solution should again be injected as before, but this time it will probably be found that high concentrations occur in the hotwell very rapidly, in which case 10 to 15 min. admission is all that is required. This should again be followed by a 15-min. "soaking" period. The short caustic admission "soaking" period cycle may be repeated as often as indicated by experience. It is suggested at the start to employ six such cycles.

The next most important phase of the procedure now follows. This is rinsing of the excess caustic soda from the machine. It is done by turning the machine at low speed (about 300 rpm) with steam and gradually introducing water into the steam to saturation, when wet saturated steam will enter the turbine. During this process, care should be taken not to drop the temperature of the turbine at a rate faster than manufacturer's specification. When wet steam begins to enter the turbine, hotwell water may become very turbid and its caustic soda and silica contents probably will increase very rapidly. We use the Hellige disk comparator for quick silica determinations in the field. During early stages of the rinse, head-end drains on the turbine casing may be opened to remove any accumulations of chemical and silica at those points without the necessity of washing them through the machine; but these drains should be closed after a short time. The course of the rinse may be followed by tests for silica and caustic soda at the hotwell. A safe end point is considered to be 10 ppm or less of caustic soda and of silica. The speed of the rinse will be controlled largely by the rate at which water is admitted to the steam after the turbine reaches saturation temperature. This is limited only by flooding of the steam line, which must be avoided.

When to Wash in Two Stages

It may be found that the procedure outlined above will not effect complete recovery of lost capacity of the turbine. Such a condition is believed to have an element of danger when the failure to recover all lost capacity is due to incomplete removal of silica. If the silica existed as hard, dense scale, the caustic may attack it slowly and the tendency is for it to come off the blades in small chips or flakes. That which does not come off may have its bond to the blade metal sufficiently weakened so that when the machine gets up to speed it will break away as larger particles. If these are sufficient in size and quantity to obstruct the spaces between blades so as to build up abnormal stage pressure drops, serious strains may be set up in the blades. Accordingly, it may be found desirable to perform a two-stage wash.

In this case, the rinse may be terminated when the caustic and silica contents of the hotwell are below 50 ppm each. The machine should then be rolled with superheated steam until at temperature equilibrium as at the start of the first cycle, care again being exercised as to rate of temperature change. The cycle of caustic injection and "soaking" period should then be resumed exactly as before except that three of the short cycles after the initial long cycle should be ample. At the conclusion, the final rinse should be to 10 ppm each of caustic and silica.

Procedure substantially as described has been so uniformly successful that when full turbine capacity is not restored it can be confidently predicted that the loss is not due to silica fouling.

Necessary Precautions

A word of caution must be mentioned for procedures relating to turbines not having a simple, straight-through steam flow. It must be borne in mind that the caustic soda carries through the turbine as a liquid in the steam. Any abrupt change in general direction of flow, as in compound machines of various types, will tend to throw out the caustic and fail to clean the blading after the change of direction. In this case, consideration should be given to multiple caustic injection—at the head end and at the point of change of direction of steam flow.

Caution also must be exercised in the case of turbines in which smaller blading follows larger, as at bleed points or in some types of compound machines. Any sizeable chips or flakes of silica washed off the larger blades may tend to lodge in the closer spacings of the smaller blades. In this case, consideration should be given to washing from the bleed point (or similar point of subsequent smaller blades) to the turbine exhaust before washing from the head end.

In returning a machine to service after a caustic wash, it should be brought up to speed and load very slowly and carefully. At least until a background of experience is acquired with each machine, it may be desirable to follow them until they are carrying full load by taking vibration readings continuously.

Since the cleaning process is essentially chemical, the services of a competent chemist, who is thoroughly familiar with power plant equipment and its operation, will be found most valuable.

If these fundamentals are painstakingly applied to each job, silica deposits can be removed from turbine blades with caustic:

1. High temperature in the turbine.
2. Adequate caustic soda. Probably 400 lb will be consumed in washing a moderate-sized unit.
3. Plenty of water during the rinse.
4. Consideration of safety of personnel and of equipment.

The Consolidated Edison Company of New York has been washing turbines with caustic soda for removal of silica deposits for about four years. Where the procedures here outlined have been followed, the machines are returned to their designed capacity. The operation now has been developed to the point that machines are chemically cleaned on a time cycle basis in rotation. Frequency of cleaning has been determined by an economic study, wherein the value of the capacity loss has been balanced against the cost of a chemical cleaning, including outage time, labor and materials.

EQUIPMENT SALES

as reported by equipment manufacturers to the Department of Commerce, Bureau of the Census

Boiler Sales

Stationary Power Boilers

	1947 Water Tube		1946 Water Tube		1947 Fire Tube		1946 Fire Tube	
	No.	Sq Ft*	No.	Sq Ft*	No.	Sq Ft*	No.	Sq Ft*
Jan.....	160	963,949	173	1,109,924	106	106,788	113	154,064
Feb.....	149	969,541	197	1,262,520	90	99,267	126	171,100
Mar.....	168	863,292	171	1,357,650	80	109,984	123	180,552
Apr.....	177‡	1,032,452‡	198	1,247,693	71	94,315	110	137,614
May.....	150	988,794	158	980,004	56	73,821	86	117,554
June.....	176‡	1,543,479‡	151	980,231	49	68,491	99	157,664
July.....	148	1,022,456	191	1,469,638	85	99,628	88	97,276
Aug.....	154	1,009,025	128	877,497	60	78,470	117	147,684
Sept.....	113	711,949	136	1,207,409	71	86,999	73	94,164
Jan.–Sept., incl....	1,395	9,104,938	1,503	10,492,566	668	891,584	935	1,257,264

* Includes water wall heating surface. ‡ Revised.

Total steam generating capacity of water tube boilers during the period Jan.–Sept. (incl.) 1947, 103,228,000 lb per hr; in 1946, 96,122,000 lb per hr.

Marine Boiler Sales

	1947 Water Tube		1946 Water Tube		1947 Scotch		1946 Scotch	
	No.	Sq Ft*	No.	Sq Ft*	No.	Sq Ft	No.	Sq Ft*
Jan.....	2	7,724	2	11,276	—	—	1	590
Feb.....	2	1,423	—	—	—	—	—	—
Mar.....	5	22,232	—	—	—	—	4	1,706
Apr.....	11	6,801	18	46,390	—	—	1	263
May.....	1	4,852	4	9,040	—	—	1	263
June.....	1	688	31	17,620	1	1,290	1	520
July.....	4	25,834	2	7,424	—	—	3	539
Aug.....	3	14,160	—	—	—	—	16	5,087
Sept.....	2	12,446	5	11,836	—	—	1	990
Jan.–Sept., incl...	31	96,160	62	103,586	1	1,290	28	9,958

* Includes water wall heating surface.

Total steam generating capacity of water tube boilers sold in the period Jan.–Sept. (incl.) 1947, 1,107,000 lb per hr; in 1946, 821,000 lb per hr.

Mechanical Stoker Sales†

	1947 Water Tube		1946 Water Tube		1947 Fire Tube		1946 Fire Tube	
	No.	Hp	No.	Hp	No.	Hp	No.	Hp
Jan.....	67	32,532	61	35,757	148	22,320	184	23,323
Feb.....	55	32,759	71	40,880	122	19,946	175	27,708
Mar.....	55	26,956	94	45,646	225	29,705	181	28,071
Apr.....	63	37,914	93	45,606	111	19,649	249	42,271
May.....	77	40,481	101	49,653	93	12,500	202	30,933
June.....	83	33,204	76	42,259	187	24,964	233	32,815
July.....	74	38,580	97	50,668	306	42,689	233	33,290
Aug.....	97	55,356	72	30,101	301	42,396	355	40,716
Sept.....	73	39,219	49	28,118	372	41,421	401	34,937
Jan.–Sept., incl.	644	342,001	714	368,688	1,865	255,590	2,213	294,064

† Capacity over 300 lb of coal per hour.

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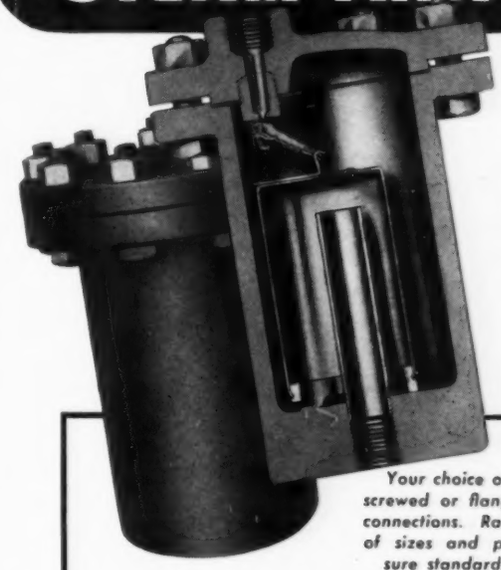

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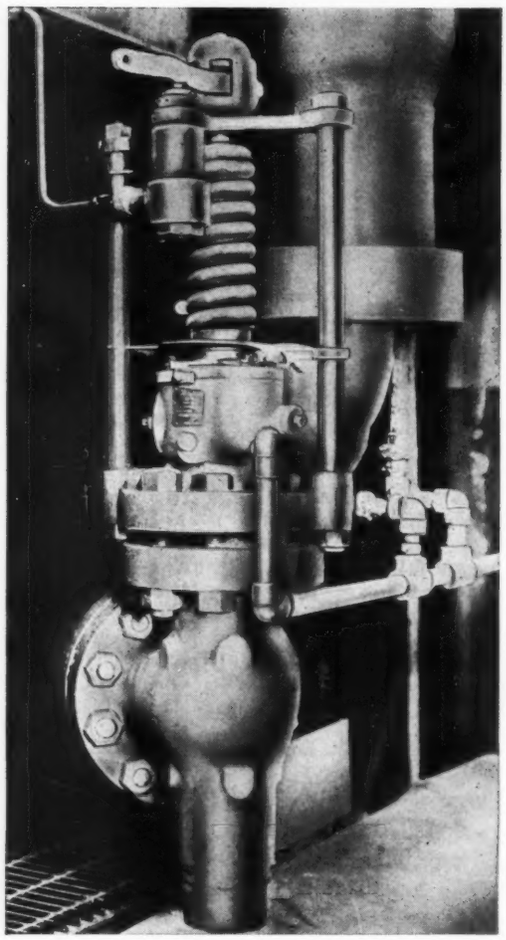

Hundreds of Foster 38-SV Safety Valves are giving top performance in important installations. This 2½" superheater unloading valve operates at 1450 lb., 950° total temp. Others are in service up to 2575 lb. at 1000° F.

1 Built to Stay on the Job—the Foster 38-SV is the SAFETY valve that is built to pop without causing boiler outages. On accelerated tests in an Eastern Utility, one of these valves has been popped every day for more than 6 years. It has had only routine maintenance, and yet it pops consistently at set pressure, and does not leak. In the Chief Engineer's own words—this is the equivalent of at least 40 years' normal service.

2 Accurate Popping—Once set at the desired popping point, the Foster 38-SV pops on the button for each successive pop. For instance, in another Utility installation, the 38-SV under test was set for 600 lb. and popped 50 times in quick succession. The first pop was at 600 lb. and the 50th pop was at 595 lb. In spite of the heat of this abnormal operation, the Foster 38-SV was thrown off less than 1%. After a short cooling period, it again popped at 600 lb. That's test gauge accuracy!

3 Minimum Blow-down—Foster 38-SV's are adjustable so they can be set to reseat when pressure has dropped as little as 1% below the popping point. In this same test the 38-SV, on its first pop, reseated at 594 lb. for a 6 lb. or 1% blow-down. On the 50th pop, it reseated at 589 lb. which is also 6 lb. or 1%. After each pop, it reseated positively with no chattering or leakage. Only over-pressure up the stack—no useful steam wasted.

4 High Relief Capacity—Foster 38-SV's have larger bore because they can handle larger volume of steam and still control blow-down. Depending on operating conditions, they may give more than twice the capacity of other makes, as in the case of 5 Foster 38-SV's required to replace 12 "conventional" safety valves of the same nominal size. Fewer valves to buy—fewer valves to service.

5 Low Maintenance—Hot or cold, the piston in the 38-SV fits loosely and cannot stick, and yet no steam reaches the spring. The spring stays cool enough to touch, even while the valve is popping—which means longer spring life. Disc and seat expand at the same rate during heating-cooling cycles—there is no drag to destroy seating surfaces. Simmering and chattering have been eliminated as a source of destruction. Discs will not warp or crack. When routine inspection and maintenance are indicated, complete loading assembly lifts out without disturbing the spring setting.

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149 MONROE STREET • NEWARK, N. J.

Federal Power Commission Urges Further Interconnection

THE following statement by the Federal Power Commission was issued on November 22 in an effort to afford a measure of relief in the prevailing threatened power shortage.

Electric companies which do not have enough power supply to meet demands, or which anticipate such difficulty, are strongly urged to take immediate steps to determine whether relief from this dilemma may be possible through interconnection with other companies or systems.

As a contribution to solution of this pressing problem which is affecting or may affect the essential electrical needs of households, commercial establishments and industries, the Federal Power Commission stands ready to (1) make available its engineering staff to advise or to take part in conferences concerning the technical aspects of possible interconnections, and (2) give quickest possible consideration to requests for authority to make interconnections for emergency purposes without subjecting the companies involved to the general regulatory jurisdiction of the Commission.

Power requirements are greater today than during the height of the war effort. When war production in 1944 was keyed to its highest pitch the demand for power reached 39.4 million kilowatts. Today it has reached 46 million kilowatts, an increase of 17 per cent over the wartime high.

It is the Commission's view that the national situation with respect to the supply of electric power is serious but that the supply available will be adequate to meet all essential needs if there is full assistance and cooperation in this situation on the part of electric companies, manufacturers of electrical equipment, state commissions, consumers and the Federal Power Commission.

The seriousness of the situation is indicated graphically on the accompanying chart showing how U. S. electric power demand has overtaken supply. On the chart the dependable capacity, including reserves, of the supply of power is related to December peak loads. The highest national demand for power regularly occurs each year during December. Last December's peak of 44.7 million kilowatts was eclipsed by the September 1947 figure of 45.3 million kilowatts. As may be seen in the figures inset in the chart, the December 1947 peak is expected to reach 49.5 million kilowatts. Dependable capacity is used as the capacity key figure on the chart because installed capacity is not always fully available to serve demands.

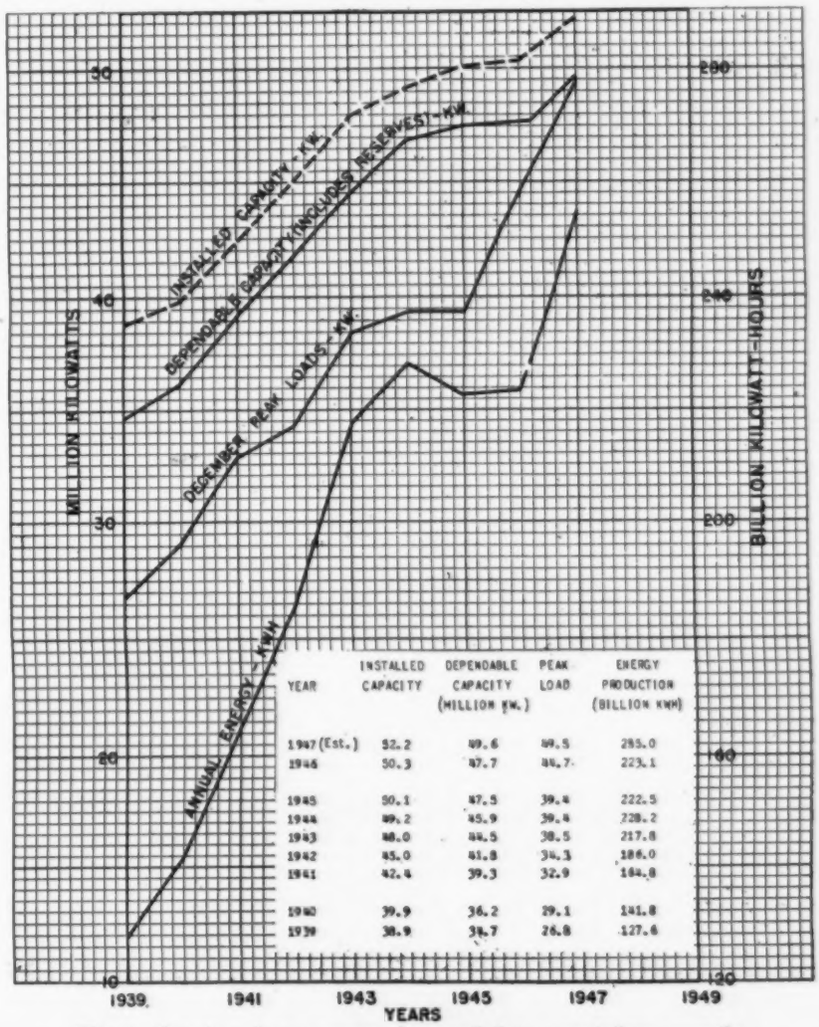
In some areas electrical power supply is now insufficient to meet demands and in all areas of the country operating reserves are extremely low. Some utilities have had to curtail the power supply of certain industrial customers and a number of utilities have had to operate at reduced voltages in an effort to make available supply reach farther than it would at normal voltages. State regulatory commissions in some instances have urged consumers to cooperate in conservation of electricity. The conditions necessitating these measures have come about despite the best efforts of companies to install needed generating facilities and of manufacturers to produce necessary equipment. Because of unavoidable installation delays due to the inability of manufacturers to turn out equipment fast enough to meet the need, the scarcity of power is expected to continue through 1948.

There are now in existence 1500 interconnections between systems, and large regional power pools are operating in New England, Pennsylvania-New Jersey, New York State, Southeastern States, Southwestern States, Central States, Pacific Northwest and the Pacific Southwest. Many other important pools of lesser capacity are also operating.

It is suggested that there are other places where advantageous interconnections could be made. For example, the utilities involved should look further into the possibilities of making new interconnections or strengthening existing interconnections within and between areas as follows: Wisconsin-Illinois-Missouri, Michigan-Ohio, Maine-New Hampshire, Western Pennsylvania, North Texas-South Texas, and Arizona-Southern California.

The Commission, therefore, urges electric utilities, both public and private, to consult further with neighboring systems to see where possible additional interconnections might be helpful. The Commission is ready to cooperate to the fullest extent possible in efforts to expand the use of interconnections. Under Section 202 of the Federal Power Act the Commission is authorized to promote interstate flow of electric energy in emergencies without subjecting the companies involved to the general regulatory jurisdiction of the Commission. Pursuant to this Section the Commission has recently authorized interconnections for emergency use to help relieve shortage conditions in the Pacific Northwest, Texas and New England.

Requests for authority to interconnect for emergency purposes will be given speedy consideration by the Commission.



YEAR	INSTALLED CAPACITY	DEPENDABLE CAPACITY (MILLION KW.)	PEAK LOAD	ENERGY PRODUCTION (BILLION KWH)
1947 (Est.)	52.2	49.6	49.5	255.0
1946	50.3	47.7	46.7	223.1
1945	50.1	47.5	39.4	222.5
1944	49.2	45.9	39.4	220.2
1943	48.0	44.5	38.5	217.8
1942	45.0	41.8	34.3	186.0
1941	42.4	39.3	32.9	164.8
1940	39.9	36.2	29.1	141.8
1939	38.9	35.7	26.8	127.6

Chart showing how power demand has overtaken supply

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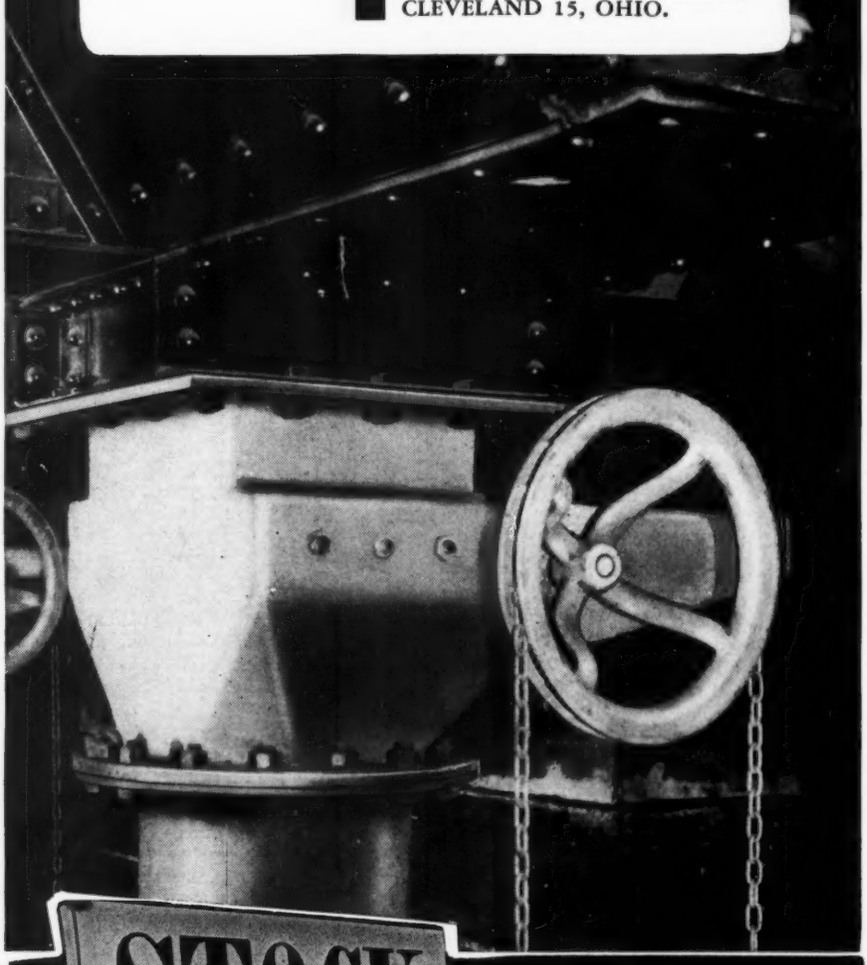

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Standardized pH Scale

The pH unit, used to express the degree of acidity or alkalinity of aqueous solutions, may be defined in a number of ways, each resulting in a slightly different value. Consequently, several pH scales, based upon various definitions, have met with equal favor among chemists. In view of the increasing need in science and industry for accurate determinations of acidity, the National Bureau of Standards is recommending the universal adoption of a single standard pH scale, analogous to the International Temperature Scale. It is proposed that the pH assigned to solutions of buffer substances distributed by the Bureau as Standard Samples be taken as the fixed points on this standard scale.

In an effort to encourage standard procedure in pH measurements, the Bureau is now supplying four buffer materials in the form of Standard Samples of certified purity. These substances are acid potassium phthalate, potassium dihydrogen phosphate and disodium hydrogen phosphate (intended to be used together), and borax. The certificates furnished with these compounds specify the pH of certain aqueous solutions of the sample, which can provide fixed points on a pH scale.

The pH of these standards is derived from measurement of the electromotive force of cells without liquid junction, in which they are used as electrolytes. These cells are specially designed, utilizing the highly reproducible hydrogen and silver-silver chloride electrodes. Computation of pH is based upon several reasonable assumed relationships between ionic activities and mean activities. These assumptions are found to give identical values for dilute solutions. The scale thus obtained approaches a true scale of activity for solutions of low concentration; at higher ionic strengths it is best regarded as a consistent scale which necessarily rests upon an assumption not subject to experimental proof.

Station Auxiliaries

I have been reading the article on "Generating Station Auxiliaries," in the October issue, and would like to submit a few comments.

In the comparison of steam vs. electric drive, this article, like some others I have read, does not mention one noticeable loss in steam drives, and that is the radiation losses from both the piping and the auxiliaries themselves, particularly where the auxiliaries are not in operation, but must be kept hot and in readiness for quick starting when needed.

When all-steam auxiliaries are used, an intricate system of piping is required, necessitating much skill and careful planning by the designer. This piping, in turn, requires provision for draining and disposal of the drains. The same applies to the exhaust from the auxiliaries. By comparison, the installation of conduits and electric cables may be a much simpler problem of design.

As to the shaft generator, the cost of the generator itself is only part of the additional cost. By increasing the overall

length of the generating unit, the size of the building may be materially increased, and a crane of longer span required. Another disadvantage of the shaft generator is that in case of an accident, it may be necessary to take the entire unit out of service.

As to an independent house turbine-generator, this is a subject that requires careful study before a definite decision is made. In the case of a power plant used as standby on a hydroelectric system, designed for quick pick-up and kept spinning on the system, the case is very strong in favor of the independent house generator. The sudden dumping of a heavy load on a steam standby plant may cause a drop in frequency that will cause either a slowing down or the loss of the electric auxiliaries at the very time that they are most required—a condition that could be avoided by the use of a house generating set. On the other hand, where the steam plant is primarily a generating plant, a house set may be an unnecessary complication.

In general, for a steam central station, I believe a safe principle to follow is to utilize all the steam at one place, and that one place is the main unit. This rule, of course, can be modified to meet the special requirements of each individual plant.

HOWARD T. LIVINGSTON
Mechanical Engineer, Dept. of Water & Power, Los Angeles

Finnish Institute in Need of Technical Literature

Finland has an excellent and keenly scientific minded Technical Institute, Teknillinen Korkeakoulu. During the war its library was bombed and totally destroyed.

On my recent trip to Finland for the American Friends Service Committee, I discussed the situation with Dr. Martti Levon, Director of the Institute. He said he would welcome gifts of scientific and technical books and periodicals from America to take the place of those destroyed. In the remarkable efforts for recovery that the Finns are making, the lack of technical library facilities is a very serious handicap. It would be a practical act of friendship to a nation that holds America in high regard if Americans should contribute good technical books and periodicals to this library.

Any such gifts should be marked for the Institute of Technology, Helsinki, and sent to the Legation of Finland, 2144 Wyoming Ave., N. W., Washington, D. C. Dr. K. T. Jutila, the Finnish Minister, will arrage for their being shipped to Finland.

ARTHUR E. MORGAN
Yellow Springs, Ohio

Midwest Power Conference

Announcement has been made that the Tenth Annual Midwest Power Conference is scheduled to be held at the Sheraton Hotel, Chicago, April 7 to 9, inclusive. As in the past, it will be sponsored by the Illinois Institute of Technology under the direction of Prof. Stanton E. Winston.

THIS new central-station boiler could have gone on the line with its 32,000 feet of tubes and 89 more of drums bared to steam and water — but it went into service with every inch of those six miles APEXIORized.

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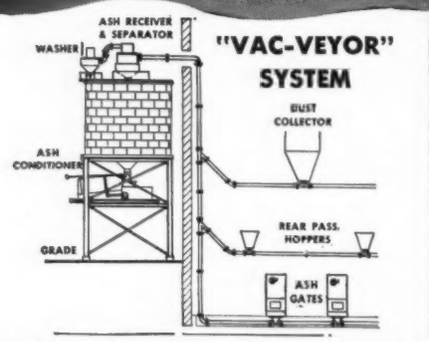

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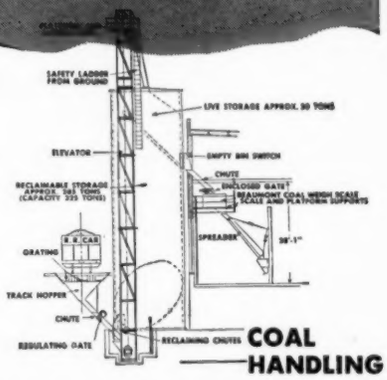
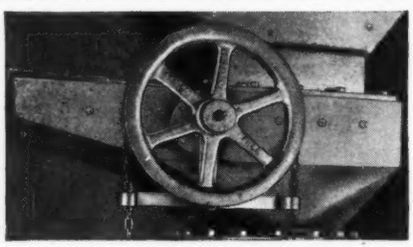
In this system, ashes, siftings, soot and dust are conveyed by pipe from the ash pits, dust collectors, stack, etc., to an ash receiver and separator at the top side of a silo—by means of a vacuum. One man operates the system, keeping your plant cleaner with less labor.



COAL HANDLING

Coal arrives by rail, is dumped into hopper, raised by bucket elevator and discharged either into bunker for immediate use or down chute to yard storage. One operator controls all equipment.



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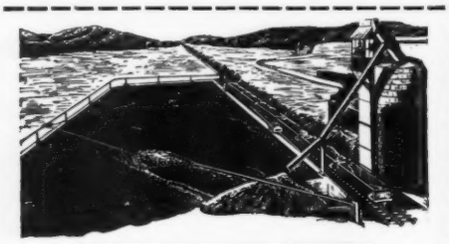

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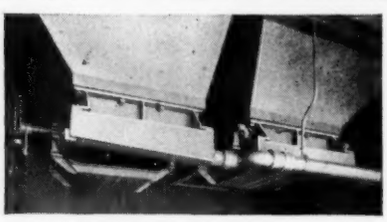

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New Books

Steam and Gas Engineering

By Butterfield, Jennings and Luce

This is the fourth edition of a book well known to the field of power engineering, particularly from the educational angle. Much of the text of the last edition has been rewritten and enlarged, particularly that dealing with thermodynamics, steam generation, turbine-generators and refrigeration. Also, in view of the recent increased importance of the gas turbine, more space has been devoted to this subject, together with the turbojet and the turbo-supercharger. Up-to-date illustrations have been substituted in many cases for those of the previous edition and the tables and charts have been amplified. Like most other books intended for classroom reference, numerous selected examples with their solutions are included. Without attempting to enumerate the twenty-four chapters, it may be said briefly that they encompass the range of heat-power engineering as taught in most technical schools.

That some of the latest developments in steam generating practice are not touched upon is probably explained by the fact that preparation of the manuscript, by the otherwise busy authors, and the mechanics of printing have required considerable time such as to antedate information that has become available on some of the latest improvements.

Aside from being a well-balanced textbook, the volume should serve as a useful reference or refresher for practicing engineers.

There are 588 pages, 6 × 9 in. Price $6.00.

A Textbook of Heat

First Edition

By G. R. Noakes

This text was prepared especially with a view to meeting the requirements of candidates for British university scholarship examinations and certain higher school certificates. It is confined largely to fundamentals without attempting to include commercial applications. In this connection, the following statement by the author perhaps best explains the approach:

"The chief difficulties experienced in the study of heat by students are not mathematical, but lie in the great care demanded to insure that the principles are properly grasped, and that simple experiments are carried out reasonably well with due regard to the limitations imposed by the apparatus. The necessity for such care has been kept before the reader continually and most of the commoner pitfalls have been pointed out."

The contents include chapters on temperature, measurement of heat, expansion of solids, liquids and gases, vapors and vapor pressure, heat and work, heat engines, liquefaction of gases, heat transfer and heat phenomena.

The book contains 469 pages, 5 × 7¾ in. with cloth binding. Price $3.00.

Air Conditioning

By Herbert and Harold Herkimer

Intended primarily for engineers concerned with air-conditioning applications, this 692-page book touches upon various phases of that industry, such as design, estimating, sales, installation, supervision, service, etc. It reviews the laws of chemistry and physics associated with air conditioning and contains chapters on such subjects as heat transfer, radiant heating, elementary thermodynamics, water vapor mixtures, fans, ducts and air distribution, heating and cooling loads, dehumidification, cooling towers, drying systems, air conditioners, automatic controls. Also included are application diagrams, numerous charts and tables and problems with their solutions.

The price is $12.

Coal and Coke Standards

The 1947 A.S.T.M. Standards on Coal and Coke, issued during October, contain in addition to some 33 specifications and 14 methods of testing, new information on expansion pressures and properties of coal during coking, as well as plastic properties and agglutinating values.

The price of this 162-page publication is $2.

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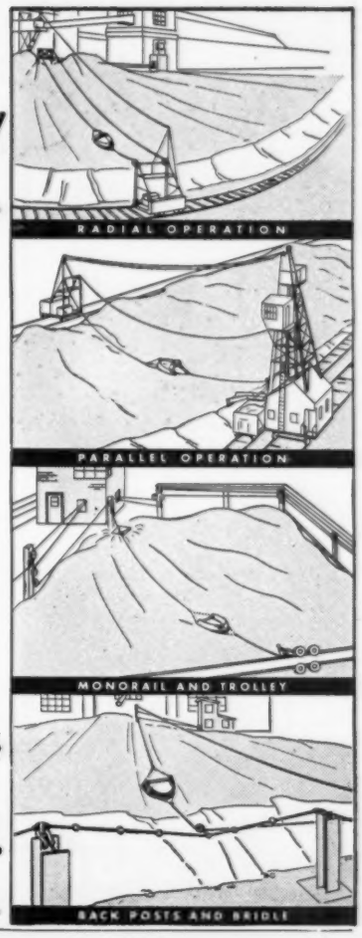

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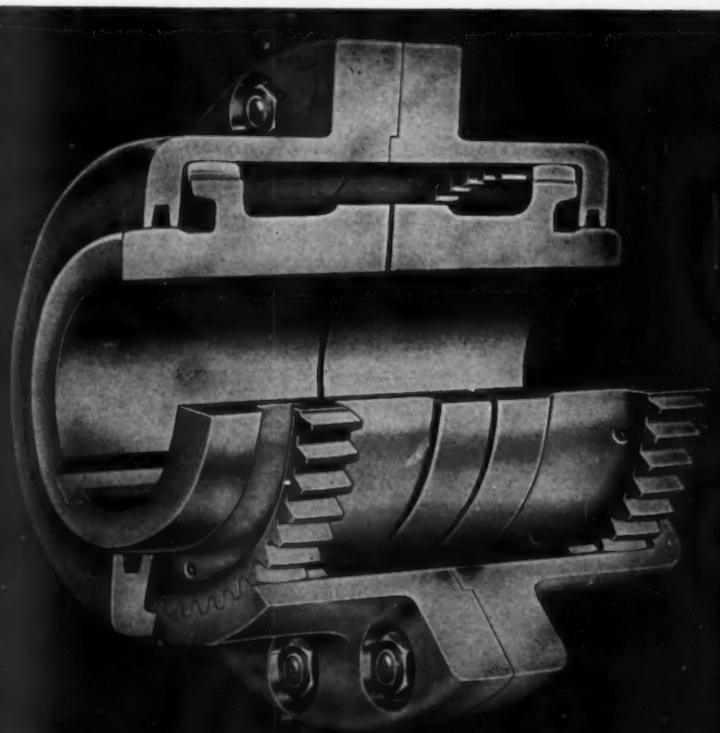

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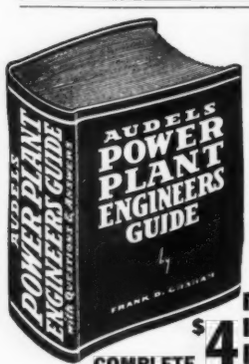

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(*Continued from page 43*)

due to the frictional forces acting during two-phase flow and (2) the pressure drop resulting from the rate of increase of momentum of the mixture as it flows through the tube and vaporizes. At higher pressures the pressure drop due to the acceleration of the fluid is a small fraction of the frictional pressure drop.

Comparison of predicted and measured pressure drops with pressures from 18 to 3300 psia and exit qualities from 4 to 100 per cent indicate that the proposed method has promise. If found reliable it should be possible to calculate pressure drop during the vaporization or condensation of liquids other than water.

President's Address

At the annual banquet on Wednesday evening, with **Dr. Blake R. Van Leer** presiding, the principal address was delivered by **Eugene W. O'Brien,** President of the Society, whose theme was "Accent on Youth." In this he stressed the need for guidance of the youthful engineer, the student and junior members, by men long in the profession. His remarks were, in part, as follows:

"We older engineers have served well in utilizing the materials of nature and in controlling its forces, but we have done poorly indeed in that other major function of our job as engineers, the directing and influencing and servicing of human nature. Our greatest concern is, or should be, the proper professional and human development of student and junior engineers into full fledged members who will constitute a better profession and better societies in the future.

"These young engineers and many more tell us that they want certain things. First of all, as becomes youth, they want action, not merely reports and surveys. Then they want protection—protection against unionization, against *trade school engineers* as they call them, against a public opinion which does not give the engineer his full due, and against an economic system that does not give him his full pay.

"They want educational guidance from practicing engineers, both in school, and more important, in the years immediately after school. They want unification of the profession and of its organizations. They often don't know what to join. They want the profession and the society to take an active human interest in them, and participation in what they are doing.

"Much of what they want and expect from the society and from older engineers they can get of their own initiative and effort. But to accomplish this end they must be led into a position of cooperation and joint activity by older members and by the society. They must become a significant working part in all of our activities. They must have occasional guidance, but still more must have a continuing interest. They must be treated with a friendly, family interest that is all too spotty at present."

Following Mr. O'Brien's talk, President-elect **E. G. Bailey** was introduced and responded briefly, saying in substance that the engineering profession should give greater attention to the broader problems, including the opportunities and obligations of the engineer to our nation, and to the world.

The dinner was the occasion of the usual conferring of honors on distinguished members of the profession.